CONTRACT DOCUMENTS
FOR THE CONSTRUCTION OF THE

WASTEWATER TREATMENT PLANT IMPROVEMENTS

CITY OF WHITE HOUSE
TENNESSEE

VOLUME 2 OF 5
SPECIFICATIONS

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PROJECT No. 708498

JUNE 2019

90% DESIGN DOCUMENTS

CITY OF WHITE HOUSE
TENNESSEE

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

WASTEWATER TREATMENT PLANT IMPROVEMENTS

Contract No. _____

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SECTION 07 11 13
BITUMINOUS DAMPPROOFING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. D1227, Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's product data for dampproofing materials.

B. Informational Submittals:

1. Manufacturer's current application instructions for dampproofing materials.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Statement of Qualification: Bituminous dampproofing installer.

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Engage experienced installer who has completed bituminous dampproofing work similar in material, design, and extent for Project.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store materials in area where temperatures are not less than 50 degrees F or over 85 degrees F.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Weather: Proceed with dampproofing Work only when existing and forecast weather conditions will permit Work. Do not apply dampproofing in rainy conditions or within 3 days after surfaces become wet from rainfall or other moisture.

B. Temperature:

1. Do not apply materials when ambient temperature is less than 50 degrees F.
2. Do not apply materials when low temperature of 40 degrees F or less is predicted within a period of 24 hours after application.

C. Ventilation: Provide adequate ventilation during application of solvent-based components in enclosed spaces. Maintain ventilation until dampproofing membrane has thoroughly cured.

PART 2 PRODUCTS

2.01 BITUMINOUS DAMPPROOFING, GENERAL

A. Odor Elimination: For interior and concealed-in-wall uses, provide type of bituminous dampproofing material warranted by manufacturer to be substantially odor-free after drying for 24 hours under normal conditions.

2.02 COLD-APPLIED ASPHALT EMULSION DAMPPROOFING

A. Asphalt Emulsion: Asphalt and water emulsion coating, formulated to penetrate substrate and build to moisture-resistant coating.

1. Nonfibrated type liquid asbestos-free emulsion; ASTM D1227, Type III.

B. Manufacturers:

1. ChemRex, Inc./Sonneborn Divisions of BASF.
2. Tremco, Inc.
3. W.R. Meadows, Inc.

PART 3 EXECUTION

3.01 SURFACE PREPARATION

A. Clean surfaces to remove dust, dirt, oil, wax, efflorescence, and other foreign materials, in accordance with dampproofing manufacturer’s instructions.

B. Allow 3 days drying time following washing down of substrate surfaces.

C. Fill cracks, voids, and honeycombs with mortar to provide sound surface for dampproofing.

3.02 APPLICATION

A. Apply dampproofing with a brush, trowel, or low pressure airless spray equipment with a coarse nozzle, as recommended by dampproofing manufacturer.

B. Apply materials at rate and as recommended by the manufacturer and in two coats.

C. Start application at top of wall and work down surface, keeping a wet edge at all times, forming a continuous, unbroken film, free from pinholes and other surface breaks.

3.03 FIELD QUALITY CONTROL

A. Inspection: Examine surfaces to receive dampproofing to assure conditions are satisfactory for application of materials.

B. After dampproofing has dried spray surfaces with water.

C. Recoat, as recommended by manufacturer, surfaces showing water absorption. To prevent blistering, protect surfaces from heat and direct sunlight until dried, then backfill.

3.04 ADJUST AND CLEAN

A. Clean spillage and overspray from adjacent surfaces as recommended by manufacturer.

3.05 APPLICATION SCHEDULE

A. Apply dampproofing to exterior of inside wythe of masonry cavity walls.

END OF SECTION

SECTION 07 21 00
THERMAL INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
   b. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's product literature identifying products proposed for use.
   b. Drawings or letter indicating proposed locations of holes for injection of foam-in-place insulation in exposed, unpainted walls.

1.03 DELIVERY, STORAGE, AND HANDLING

A. On packaging clearly identify manufacturer, contents, brand name, applicable standard, and R-value.

B. Store materials off ground and keep them dry. Protect against weather, condensation, and damage.

PART 2 PRODUCTS

2.01 BATT INSULATION AND FASTENERS

A. Fiberglass or Mineral Wool Batts:

1. ASTM C665, II, Class C, with 1.0 perm rating, nonreflective kraft paper vapor-resistant membrane laminated to one side with R-values of 25.
2. Manufacturers:
   a. CertainTeed Corp.
   b. Owens-Corning Insulating Systems.
   c. Johns Manville.

B. Fasteners: As recommended by insulation manufacturer.

C. Tape: As recommended by insulation manufacturer.

2.02 MASONRY FILL INSULATION

A. Foam-in-Place Insulation:

1. R-Value at 1-Inch Thickness: 4.6, minimum.
2. Surface Burning Characteristics, ASTM E84:
   a. Flame Spread: 25, maximum.
   b. Smoke Developed: 200, maximum.
3. Manufacturers and Products:
   a. cfiFoam, Inc.; Core Foam Masonry Foam Insulation.
   b. C.P. Chemical Co., Inc.; Tripolymer PRMIU or 105.
   c. Tailored Chemical Products; Core-Fill 500.

2.03 WALL CAVITY RIGID INSULATION

A. Expanded Polystyrene Foam:

1. R-Value 7.6, minimum.
2. ASTM C578, Type IX.
3. Flame Spread: Less than 25 when tested in accordance with ASTM E84.
4. Thickness: 2 inches.
5. Manufacturers and Products:
   a. Atlas EPS, Atlas Roofing Corp.; ThermalStar.
   b. ACH Foam Technologies; Foam-Control Plus+.

B. Adhesives and Fasteners: As recommended by insulation manufacturer.

PART 3 EXECUTION

3.01 BATT INSULATION

A. Install in accordance with manufacturer's instructions and as specified below:

1. Install in widths required by framing spacing with vapor retarder facing warm side.
2. Fit tightly to ensure continuous seal. Tape overlapping flanges of vapor retarder when necessary, using tape as recommended by insulation manufacturer.

3. Where electrical outlets, ducts, pipes, vents, or other utility items occur, place insulation on cold weather side of obstruction.
4. Protect installed insulation from tears and other damage until covered with finish material.
5. Remove and replace damaged material.

3.02 FOAM-IN-PLACE INSULATION:

A. Inject foam into ungrouted cells of concrete masonry units through holes drilled in mortar joints at interior face of wall in accordance with manufacturer's instructions. Locate holes in inconspicuous locations as approved by Engineer.

B. Upon completion, clean excess foam from face of masonry in accordance with manufacturer's instructions.

C. Fill and patch holes with mortar in accordance with Section 04 22 00, Concrete Unit Masonry.

3.03 RIGID INSULATION

A. Install in accordance with the following:

1. Install boards in location and in thickness as specified.
2. Cut insulation with saw, knife, or other sharp tool to fit tightly around obstructions.
3. Butt insulation boards together tightly at joints.
4. Where thickness required exceeds 1-1/2 inches, install two layers of boards.
5. Apply to masonry or concrete with adhesive recommended by insulation manufacturer:
   a. Adhere first layer to substratum, then adhere second layer to first, staggering joints.
   b. Follow manufacturer's recommendations for preparing surfaces and applying adhesive.

END OF SECTION

SECTION 07 26 16
BELOWGRADE VAPOR RETARDERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 302, Guide for Concrete Floor and Slab Construction.
2. ASTM International (ASTM):
   a. D412, Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension.
   b. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
   c. D903, Standard Test Method for Peel or Stripping Strength of Adhesive Bonds.
   d. D1709, Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method.
   e. D3767, Standard Practice for Rubber – Measurement of Dimensions.
   f. D4833, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
   g. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
   h. E154, Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or a Ground Cover.
   i. E1643, Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs.
   j. E1745, Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.
   k. F1249, Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s material specifications.

B. Informational Submittals: Manufacturer’s written instructions for preparation, installation/application, repair, protection and maintenance.

PART 2 PRODUCTS

2.01 UNDERSLAB VAPOR RETARDER

A. Meet or exceed ASTM E1745, Class A, with the following properties:

1. Water Vapor Permeance: 0.03 perm maximum when tested in accordance with ASTM E96/E96M or ASTM F1249.
2. Tensile Strength: 45-foot-pounds per inch minimum, when tested in accordance with ASTM D882.
3. Puncture Resistance: 2,200 grams minimum, when tested in accordance with ASTM D1709.
4. Thickness: 10 mils minimum, in accordance with ACI 302.

B. Manufacturers and Products:

1. Fortifiber Building Systems Group; Moistop Ultra 10.
2. Reef Industries, Inc.; Griffolyn 10 mil Green.
3. Stego Industries, LLC; Stego Wrap Class A Vapor Retarder.

2.02 ANCILLARY MATERIALS

A. Fasteners, Tape, Adhesive, or Sealant: As recommended by vapor retarder manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine conditions of substrates and other conditions under which work is to be performed. Do not proceed with work until satisfactory conditions are obtained.

3.02 INSTALLATION

A. Underslab Vapor Retarder:

1. Apply in accordance with manufacturer’s instructions.
2. After base for slab has been leveled and tamped, apply vapor retarder with roll width parallel to direction of concrete pour.
3. Lap vapor retarder over footings and seal to foundation walls.
4. Overlap joints 6 inches and seal with tape.
5. Seal penetrations with pipe boots.
6. Repair damaged areas with patches of vapor retarder, overlapping damaged area by 6 inches and sealing sides of patch with tape.

3.03 CLEANING

A. Upon completion of vapor retarder installation, remove waste materials and debris resulting from this operation and dispose offsite.

END OF SECTION

SECTION 07 41 13
METAL ROOF PANEL ASSEMBLY

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Insulated metal roof panel assembly from deck to metal standing seam panel and snap cap roofing design are covered by this Specification:

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C1311, Standard Specification for Solvent Release Sealants.
   c. D226, Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
   d. D523, Standard Test Method for Specular Gloss.
   e. D1970, Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection.
   f. D2178, Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing.
   g. E903, Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres.
   h. E1646, Standard Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference.
   i. E1680, Standard Test Method for Rate of Air Leakage through Exterior Metal Roof Panel Systems.
2. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): Architectural Sheet Metal Manual.
3. Underwriters Laboratories Inc. (UL): 580, Standard for Tests for Uplift Resistance of Roof Assemblies.

1.03 SYSTEM DESCRIPTION

A. The structural drawings show International Building Code (IBC) and ASCE 7-10 based values for the three zones of the roof.

B. Design Requirements: Provide licensed Alabama professional engineering services needed to design roof system installation and assume engineering responsibility if third party testing installation will not be followed literally.

C. Performance Requirements:

1. Developed wind pressure of roofing assembly per IBC and ASCE-10: See General Structural Notes on the Drawings.
2. Air Infiltration: Air leakage through assembly of not more than**:** 0.06 cfm/square foot of roof area when tested in accordance with ASTM E1680 and ASTM E283 at the following test pressures:
   a. Test Pressure:
      1) Roof slope less than or equal to 30 degrees: Negative 66 pounds per square feet.
   b. Preload Test-Pressure Difference:
      1) Positive: Greater than or equal to 15 lb ft/square feet and the greater of 75 percent of building live load or 50 percent of building design positive wind pressure difference.
      2) Negative: 50 percent of design wind uplift pressure difference.
3. Wind Uplift Resistance: Provide metal panel assemblies that comply with UL 580 for appropriate class.
4. Structural Performance:
   a. Provide metal roof panel assemblies capable of withstanding the design loads as shown on Structural Drawings.
   b. Deflection Limits: Engineer roof panel assemblies to withstand design loads with vertical deflections no greater than 1/180 of span.
5. Thermal Movement: Provide metal roof panel assemblies that allow for thermal movement resulting from temperature change of 120 degrees F (67 degrees C), ambient and 180 degrees F (100 degrees C), material surface.
   a. Solar reflectance for roof slopes over 2:12:
      1) Initial: Not less than 0.25.
      2) Maintained: Not less than 0.15 for 3 years after installation.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Proposed roof assembly must be documented by third party testing as meeting positive and negative developed wind pressures per International Building Code, 2015 Edition as a minimum.
   b. Drawings showing thickness and dimensions of parts and accessories, fastening and anchoring methods, roof penetrations, details, and locations of seams, joints, and other provisions for thermal movement. Distinguish between factory-assembled and field-assembled work. Include drawings at not less than 1/4-inch to 1-foot scale and details at not less than 3-inch to 1-foot scale.
   c. Assembly products name and specifications clearly identified including vapor retarder, insulation, cover boards, clips and metal roofing panel.
2. Samples: 12-inch square Samples of specified metal. Samples will be reviewed for color and texture only.

B. Informational Submittals:

1. Manufacturer's printed installation instructions
2. A letter from roofing manufacturer stating roofer is approved by manufacturer to apply the roof.
3. Copy of special guarantee.
4. Licensed Alabama Engineer's signed and sealed calculations for connector pattern and installation based on required uplift pressure.
5. Pre-installation Conference meeting minutes.
6. Special guarantee.

1.05 QUALITY ASSURANCE

A. Applicator's Qualifications: Approved and trained by materials manufacturer.

B. Engineer Licensed in the State of Florida engineering the installation requirements for the proposed roof system to meet required uplift pressures.

C. Pre-installation Conference:

1. Before starting metal roof installation, conduct a conference with Engineer, roofing applicator, roofing system materials manufacturer, and Owner's insurer, Subcontractors likely to be on roof, and installers whose work affects metal roof installation.

2. Items to be reviewed and discussed include, but are not limited to, the following items:
   a. Examine roof deck or substrate conditions for compliance with requirements for flatness and tolerance of structural members.
   b. Review structural loading limitations of roof deck or purlins and rafters during roofing installation.
   c. Review flashing details, roof drainage, roof insulation, roof penetrations, roof-mounted mechanical equipment, and other construction and conditions that might affect metal roof panel installation.
   d. Review governing regulations and requirements for insurance, certificates, and testing and inspecting as applicable.
   e. Review temporary protection requirements for metal roof panels during and after installation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver components and metal roof panels so as not to be damaged or deformed. Package for protection during transportation and handling.

B. Storage and Handling:

1. Protect against damage and discoloration.
2. Handle panels with non-marring slings.
3. Do not bend panels.
4. Store panels aboveground on pallets or platforms, with one end elevated for drainage.
5. Protect strippable protective covering from exposure to sunlight except as necessary for metal roof installation.
6. Stack panels to prevent twisting, bending, or abrasion, and to provide ventilation.
7. Protect panels against standing water and condensation between adjacent surfaces.
8. If panels become wet, immediately separate sheets, wipe dry with clean cloth, and separate sheets for air-drying.
9. During storage prevent contact with materials that may cause discoloration or staining.

1.07 COORDINATION

A. R-25 min. roof insulation is considered part of roof assembly.

B. Coordinate installation of roof curbs, equipment support, and other roof accessories as specified in Section 07 70 01, Roof Specialties and Accessories.

C. Coordinate metal roof installation with flashing and trim as specified in Section 07 62 00, Sheet Metal Flashing and Trim.

D. Coordinate work with construction of decks, walls, and other adjoining work.

1.08 SPECIAL GUARANTEE

A. Product: Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction or, at the option of the Owner, removal and replacement of roofing panels, flashing, finish, and accessories found defective during a period of 20 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified the General Conditions.

B. Conditions:

1. Roofing Panels: No rupture, structural failure, or perforation.
2. Finish: No cracking, blistering, flaking, chipping, checking, chalking, peeling, or fading.
3. Components: Watertight and weathertight with normal usage.

C. Installer's 3 year warranty covering roof panel installation for watertightness.

PART 2 PRODUCTS

2.01 ROOFING PANELS

A. Material: Aluminum Panel System.

B. Slope: As shown on Drawings.

C. Surface: Embossed finish.

D. Finish:

1. 2-Coat Fluoropolymer AAMA 621, Fluoropolymer finish containing not less than 70 percent PVDF resin by weight color. Manufacturers' approved applicator to prepare, pretreat mill metal and apply coating.
2. Coating system shall provide nominal 1.0 mil dry film thickness consisting of primer and color coat.

E. Concealed Finish: Apply pretreatment and standard manufacturer white or light colored polyester backer finish consisting of prime coat and finish coat with total dry film thickness of 0.5 mil.

F. Color: As indicated in Exterior Finish Schedule.

G. Manufacturers and Assemblies:

1. Factory-formed metal roof panels with vertical ribs at panel edges and intermediate stiffening ribs symmetrically space between vertical ribs; designed for sequential field installation by mechanically attaching panels to supports using concealed clips located under one side of panel and engaging opposite edge of adjacent panels and snapping together.
2. Manufacturer: Petersen Aluminum: Snap Clad Plus:
    a. Panel Coverage: 16 inches.
    b. Panel Height: 1.75 inches.
    c. Wind Pressure: As shown on Drawings.
    d. Insulation: Minimum 3/4 inches thick and maximum 4 inches thick with #14 pancake head screws long enough to penetrate deck through 3-inch diameter insulation plates.
    e. Coverboard: 1/2-inch DensDeck Roof Board over insulation with #14 pancake head screws long enough to penetrate deck through 3-inch diameter insulation plates.
    f. Underlayment: Quick-Stick HT self-adhering underlayment. Clip spacing and attachment to deck thru insulation per Peterson Aluminum Products engineering for pressure required per structural design criteria.
    g. GreenGuard by Kingsspan and Rdeck insulation board 3 by RMax. R-Value: R-25.
3. Other Systems Standing Seam with Snap on Cap
    a. Other manufacturers submitted as equals must meet all requirements stated in this specification.
    b. The following are other acceptable manufacturers:
        1) Manufacturer: (Imetco) Innovative Metals Company Inc.
        2) Products: Series 300, 040 Aluminum Non-Structural Roof Panel Standing Seam Metal Roof- Aluminum.
            a) Panel Coverage: 12 inches.
            b) Panel Height: Minimum 1.5 inches.
            c) Wind Pressure: As shown on Drawings.
            d) Clip spacing and attachment to deck thru insulation per Imetco Products engineering for pressure stated.

2.02 ALTERNATE INDIVIDUAL ASSEMBLY PRODUCTS

A. Alternate roofing assembly products such as Palisade Synthetic Roof Underlayment manufactured by SDP Advanced Polymer Products Inc. (Miami Dade Notice of Acceptance # 11-0714.05) may only be used if allowed by third party testing documentation.

2.03 METAL SOFFIT PANELS

A. General: Provide factory-formed metal soffit panels designed to be field-assembled by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fastening and factory-applied sealant in side laps; included accessories for a complete, weathertight installation.

B. Match finish, color, material, and profile of metal roof panels.

C. V-Groove Profile: Solid panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges with V-groove between panels.

1. Material: Aluminum-zinc alloy coated sheet 24-gauge or aluminum sheet: 0.032-inch minimum metal thickness.
2. Finish: Fluoropolymer.
3. Color: As selected from manufacturer’s standard color range or as scheduled on Finish Schedule on Drawings.
4. Panel Coverage: 12 inches.
5. Panel Height: 0.50 inch.
6. Manufacturers:
    a. Imetco.
    b. Berridge Manufacturing Co.
    c. Petersen Aluminum Corp.

2.04 ACCESSORIES

A. Slip Sheet: Coated-glass fiber fire-resistant slip sheet as recommended by sheet metal roofing manufacturer.

B. Holddown Clips: System manufacturer’s ASTM A792/A792M standard shape steel.

C. Closures: Manufacturer’s standard neoprene blocks shaped to fit roof metal profile.

D. Sealant.

1. Joint Sealant: Type 5 as specified in Section 07 92 00, Joint Sealants or Type 6 as specified in Section 07 92 01, Sealants and Caulking.
2. Silicone Sealant: Type 1 as specified in Section 07 92 00, Joint Sealants.
3. Tape Sealant: Type 13 as specified in Section 07 92 00, Joint Sealants.
4. Butyl Sealant: Butyl-rubber based, solvent-release sealant per ASTM C1311.

E. Isolation Paint: As specified in Section 09 90 00, Painting and Coating.

2.05 FABRICATION

A. Fabricate and finish metal roof panels and accessories at factory to the greatest extent possible.

B. Provide panel profile, including major ribs and any intermediate stiffening ribs for full panel length.

C. Panel Length: Roof panels shall be full length from eave to ridge, unless otherwise indicated or limited by shipping limitations. Form and fabricate sheets, battens, strips, cleats, valleys, ridges, edge treatments, integral flashings, gutters, downspouts, and other components of specified metal roofing panels to profiles, patterns, and drainage arrangement shown, and as required for permanent leakproof construction, and as recommended by SMACNA's "Architectural Sheet Metal Manual and manufacturer."

D. Provide for thermal expansion and contraction of Work.

E. Conceal fasteners and methods of expansion where possible. Do not use exposed fasteners on faces of accessories where exposed to view.

F. Finishes:

1. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
2. Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half the range of approved sample. Noticeable variations within same piece are not acceptable. Variations in other component appearances are acceptable if within range of approved samples and are assembled or installed to minimize contrast.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with alignment tolerances required by metal roof panel manufacturer.

B. Prior to beginning installation, examine rough-in location for items penetrating metal roof panels and coordinate with seam locations.

3.02 PREPARATION

A. Deck: Firm, dry, free of foreign materials, and smooth. Report immediately to Engineer cracks, breaks, holes, or other unusual irregularities in surface.

B. Layout Pattern:

1. Lay out to place seams equidistant from corners and aligned with seams on other side of hip or ridge.
2. Coordinate Work of this section with flashing, trim, and other construction to provide a permanently leakproof, secure, and noncorroding installation.

3.03 INSTALLATION

A. General:

1. Apply roofing only in dry weather and where weather conditions permit.
2. Install in accordance with manufacturer's written instructions and warranty requirements coupled with any other Factory Mutual requirements.
3. Comply with recommendations of the SMACNA "Architectural Sheet Metal Manual" in any metal fabrications required.
4. Install metal roofing and soffit system consisting of nonstructural sheet metal panels held to substrate with concealed fasteners.
5. Conceal expansion joint provisions wherever possible in exposed Work; locate so as to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.

6. Closures and Trim:
    a. Provide ridges, hips, valleys, eaves, rakes, fascia, gutters, downspouts, and other exposed trim and flashing for a weather-tight roofing and soffit system.
    b. Provide metal closures at peaks, rake edges, rake wall and each side of ridge and hip caps.
    c. Flash and seal metal roof panels with weather closures at eaves, rakes, and at perimeter of openings. Fasten with self-tapping screws.
7. Install ridge and hip caps as the metal roof panel work proceeds.
8. Dissimilar Metals:
    a. Separate from each other where electrolysis might occur.
    b. Separate metal panels where contact with corrosive substrates may occur.
    c. Separation is satisfactorily accomplished by coating metals with isolation Paint.
    d. Comply with various metals producers' recommendations for other forms of protection against contamination from corrosive materials or agents.
9. Locate panel splices, if occur, over structural supports. Do not fasten. Stagger panel splices and end laps to avoid a four-panel lap splice condition. At cross seams, form with 3/4-inch fold under on lower end and 2-inch fold over on upper end. Slit folds in cross-seams at each corner 1 inch in from seam to form tab. Use holddown cleats at cross seams. Hook fold on lower end of panel into fold on upper end of underlaying panel. Use two cleats per panel width.
10. Lap metal flashing over metal roof panels to allow moisture to run over and off the material.
11. Cutting and Fitting: Neat, square, and true. Saw cut panels, deburr, and use touchup paint immediately as recommended by roofing panel manufacturer. Torch cutting is prohibited.
12. Valleys:
    a. Form of sheets not exceeding 10 feet in length. Lap joints 6 inches in direction of drainage.
    b. Extend valley sheet minimum 6 inches under roofing sheets.
    c. At valley, double fold valley and roofing sheets, and secure with cleats spaced 18 inches on center.

B. Underlayment and Slip Sheet:

1. Install underlayment and slip sheet on roof sheathing, unless otherwise recommended by metal roof panel manufacturer.
2. Apply underlayment single-ply lapped shingle fashion, 3 inches at head and 6 inches at sides.

3. Cover with loose-laid slip sheet similarly lapped and with joints staggered.
4. Install no more than can be covered by metal roofing or other approved protection, in same day.
5. Use adhesive for temporary anchorage, where possible, to minimize use of mechanical fasteners under metal roof panels.

C. Standing-Seam and Batten-Seam Metal Roof:

1. Install as recommended by metal roof panel manufacturer's installation instructions and recommendations.
2. Begin at eaves. Rigidly fasten eave end of metal roof panels and allow ridge end free movement for thermal expansion and contraction.
3. Install clips in panel side joints at location, spacing, and with fasteners as recommended by manufacturer for type of substrate and wind loading specified.

D. Metal Soffit Panels:

1. Perforated soffit panels/porch ceilings to ventilate areas above soffits which are detailed to be isolated from interior air space of building.
2. Provide full width of soffit. Install perpendicular to support framing. Flash and seal panels with weather closures where metal soffit panels meet walls and at perimeter of openings and joints.

3.04 CLEANING AND PROTECTION

A. Cleaning:

1. At the end of each day sweep metal clean of foreign materials, especially metal particles and scrap.
2. Peel off strippable film.
3. Where needed, clean metals in conformance with metals industry recommendations or use Basic H organic metal cleaner, Shaklee Products, Hayward, CA.

B. Protection:

1. Protect material from exposure to chlorides, hydrochloric-based and muriatic acids. If contaminated, wash affected areas immediately with 5 percent soda and water solution and rinse with clear water.
2. Avoid walking on roof after completion.

C. Final Cleanup:

1. Remove debris, metal clips, nails, and other materials that could prevent adequate drainage or produce corrosion products through electrolysis.
2. Repair and touchup damage.
3. Replace metal roof panels that have been damaged or have deteriorated beyond successful repair.

END OF SECTION

SECTION 07 62 00
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C920, Standard Specification for Elastomeric Joint Sealants.
   c. C1311, Standard Specification for Solvent Release Sealants.
   d. D1187/D1187M, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   e. D4586/D4586M, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
2. Federal Specifications (FS): QQ-L-201F(2), Lead Sheet.
3. FM Global (FM): Loss Prevention Data Sheet 1-49, Perimeter Flashing.
4. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): 1793, Architectural Sheet Metal Manual.

1.02 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing, rattling, leaking, and fastener disengagement.

B. Thermal Movements:

1. Provide sheet metal flashing and trim that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures for preventing buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects.
   a. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.
2. Provide clips that resist rotation and avoid shear stress as a result of sheet metal and trim thermal movements.
3. Base engineering calculation on surface temperatures of materials as a result of both solar heat gain and nighttime-sky heat loss.

C. Water Infiltration: Provide sheet metal flashing and trim that does not allow water infiltration to building interior.

1.03 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA 1793. Conform to dimensions and profiles shown, unless more stringent requirements are indicated.

1.04 DESIGN REQUIREMENTS

A. Wind Loads: Provide sheet metal and trim assemblies and their anchorage to the building structure that are capable of withstanding the positive and negative wind load pressures shown on the Components and Cladding Wind Surface Pressures table on the Structural Drawings.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Show joints, types and location of fasteners, and special shapes.
   b. Catalog data for stock manufactured items.
2. Samples: Color Samples for items to be factory finished.

B. Informational Submittals: Third party testing documentation or manufacturer's literature qualifying sheet metal and trim assemblies and their anchorage to the building structure as meeting the required developed wind pressures for Project as shown on the Components and Cladding Wind Surface Pressures table on the Structural Drawings.

1.06 DELIVERY, HANDLING, AND STORAGE

A. Inspect for damage, dampness, and wet storage stains upon delivery to Site.

B. Remove and replace damaged or permanently stained materials that cannot be restored to like-new condition.

C. Carefully handle to avoid damage to surfaces, edges, and ends.

D. Do not open packages until ready for use.

E. Store materials in dry, weathertight, ventilated areas until immediately before installation.

1.07 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction or, at the option of the Owner, removal and replacement of factory-applied fluoropolymer coating, finish, and accessories found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

B. Conditions:

1. Finish: No cracking, blistering, flaking, chipping, checking, chalking, peeling, or fading.
2. All Components: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 METAL

A. Prefinished Aluminum Sheet: ASTM B209, alloy and temper as required for application and finish: 0.032-inch thick; mill finish; shop precoated with fluoropolymer coating (Kynar polyvinylidene fluoride resin) coating; color as selected from manufacturer's standard color range.

2.02 GUTTERS AND DOWNSPOUTS

A. Fabricated from prefinished aluminum sheet specified in this section.

2.03 ANCILLARY MATERIALS

A. Sealing Tape: Polyisobutylene sealing tape specifically manufactured for setting flanges on bituminous roofing.

B. Isolation Paint: ASTM D1187/D1187M, asphalt.

C. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil thick minimum polyester.

D. Plastic Roof Cement: ASTM D4586/D4586M, Type II.

E. Elastomeric Sealant: ASTM C920, elastomeric silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

F. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, heavy bodied for hooked-type expansion joints with limited movement.

G. Fasteners:

1. Aluminum Work: Stainless steel or aluminum.
2. Stainless Steelwork: Stainless steel.

2.04 FABRICATION OF FLASHING

A. Field measure prior to fabrication.

B. Fabricate in accordance with SMACNA 1793 that applies to design, dimensions, metal, and other characteristics of item indicated.

C. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.

D. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

E. Seams:

1. Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

F. Reinforcements and Supports: Provide same material as flashing, unless other material is shown. Steel, where shown or required, shall be galvanized or stainless.

G. Rigid Joints and Seams: Make mechanically strong. Seal aluminum joints with sealant.

H. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

I. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1-inch deep, filled with butyl sealant concealed within joints.

J. Fabricate sheet metal in 10-foot maximum lengths, unless otherwise indicated.

K. Provide watertight closures at exposed ends of counterflashing.

L. Fabricate corners in one-piece with legs extending 30 inches each way to field joint. Lap, rivet, or solder corner seams watertight. Apply sealant if necessary.

M. Solvent clean sheet metal. Surfaces to be in contact with roofing or otherwise concealed shall be coated with isolation paint.

N. Pipe Penetrations through Roof: Flash with lead.

O. Conceal fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.

P. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

1. Thickness: As recommended by SMACNA 1793 and FM Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

2.05 FABRICATION OF GUTTERS AND DOWNSPOUTS

A. Form downspouts in maximum lengths as practicable to sizes and shapes indicated on Drawings:

1. Telescope end joints 1-1/2 inches and lock longitudinal joints of downspouts.
2. Provide elbows at bottom where downspouts empty onto splash blocks.
3. Fit downspouts into cast iron boots or drainpipes where indicated on Drawings; neatly caulk or cement joints.

B. Form scuppers and conductor heads to shapes and sizes indicated on Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set and cant strips and reglets in place.

B. Verify nailing strips and blocking are properly located.

C. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 INSTALLATION

A. Flashing:

1. General:
    a. Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA 1793.
    b. Provide concealed fasteners where possible, set units true to line, and level as indicated.
    c. Install work with laps, joints, and seams that will be permanently watertight.
2. Isolate metal from wood and concrete and from dissimilar metal with isolation tape or two coats of isolation paint.
3. Use only stainless steel fasteners to connect isolated dissimilar metals.
4. Joints: 10-foot maximum spacing and 2-1/2 feet from corners, butted with 3/16-inch space centered over matching 8-inch-long backing plate with sealing tape in laps.
5. Set flanges of flashings and roof accessories on continuous sealing tape or in plastic roof cement on top of envelope ply of roofing. Nail flanges through sealing tape and at 3-inch maximum spacing. Touch up isolation paint on flanges.
6. Joints, Fastenings, Reinforcements, and Supports: Sized and located as required to preclude distortion or displacement as a result of thermal expansion and contraction.
7. Provide continuous holddown clips at counterflashing and gravel stops.
8. Conceal fastenings wherever possible.
9. Set flashing and sheet metal to straight, true lines with exposed faces aligned in proper plane without bulges or waves.

B. Downspouts, Scuppers, and Conductor Heads: Anchor downspouts to wall with straps of same material as downspouts. Install scuppers, and conductor heads as indicated on Drawings.

3.03 FINISH

A. Exposed Surfaces of Flashing and Sheet Metalwork: Free of dents, scratches, abrasions, or other visible defects, and clean and ready for painting where applicable.

3.04 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean off excess sealants.

C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain in a clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 70 01
ROOF SPECIALTIES AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association International (AMCA).
2. American Architectural Manufacturers Association (AAMA).
3. ASTM International (ASTM):
   a. D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   b. D4586, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
4. FM (Factory Mutual) Global (FM).
5. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings of each item specified showing materials, details, flashing, anchorage, and relation to adjacent structure.
2. Catalog cuts of each item specified item.

B. Informational Submittals: Manufacturer's Certificate of Compliance per Section 01 61 00, Common Product Requirements, (or alternately, test results or calculations) that assure item's and its anchorage's design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

1.03 SEQUENCING AND SCHEDULING

A. Coordination: Schedule and coordinate work of this section with work of Section 07 41 13, Metal Roofing Panels and Section 07 62 00, Sheet Metal Flashing and Trim.

PART 2 PRODUCTS

2.01 EQUIPMENT SUPPORT CURBS

A. Prefabricated Galvanized Steel: Minimum 12-inch-high curb with counterflashing, factory installed insulation, and treated wood nailer as required for conditions shown on Drawings.

B. Metal Gauge and Reinforcement: To suit imposed loads of equipment to be supported.

C. Fabricate curbs to fit roof slope.

D. Manufacturers and Products:

1. Pate Co.; ES-2.
2. ThyCurb; Model TEMS-3.
3. RPS Corporation; ER-2A.

2.02 VENT PIPE FLASHING

A. Prefabricated flashing with elastomeric collar and 0.032-inch aluminum base, sized to fit vent pipe.

B. Manufacturer and Product: Oatey; No-Caulk Roof Flashing.

2.03 ANCILLARY MATERIALS

A. Isolation Paint: ASTM D1187, asphalt.

B. Coat aluminum surfaces in contact with concrete or dissimilar metals as specified in Section 09 90 00, Painting and Coating.

C. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil-thick minimum polyester.

D. Fasteners: Stainless steel of type required.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine surfaces and structures to receive the Work of this section.

B. Take measurements at Site and fabricate work to suit. No changes shall be made in supporting structure to accommodate this Work.

3.02 INSTALLATION

A. General:

1. Install roof specialties and accessories as detailed in approved shop drawings and in conformance with manufacturer's instructions, recommendations, and standards.
2. Use appropriate vent pipe flashing where pipes penetrate roofing.

3. Use appropriate flashing where ductwork connects to existing roof curbs.
4. Where support curbs are installed on existing roofing provide appropriate flashing in accordance with the existing roofing system manufacturer for a weathertight installation.
5. Factory Finished Units: Place color variations in pieces so no extremes are next to each other.
6. Make Work weathertight and free of expansion and contraction noise.
7. Maintain separation between aluminum surfaces and concrete or dissimilar metals with isolation paint.

END OF SECTION

SECTION 07 84 00
FIRESTOPPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM): E814, Test Method for Fire Tests of Through-Penetration Firestops.
2. Underwriters Laboratory, Inc. (UL):
   a. 1479, Fire Tests of Through-Penetration Firestops.
   b. 2079, Tests for Fire Resistance of Building Joint Systems.

1.02 SYSTEM DESCRIPTION

A. Provide systems of material or combination of materials used to fill openings around penetrating items to prevent the spread of fire and retain integrity of fire rated construction by maintaining an effective barrier against spread of flame, smoke, water, and hot gases through penetrations in fire rated wall and floor assemblies.

B. Provide Fire Safing:

1. At slot gaps between edge of floor slabs and exterior walls.
2. Gaps between top of walls and structure above.
3. Expansion joints in walls, floors, and ceilings.

C. Performance Requirements: Provide firestop systems with materials that have been manufactured and installed to maintain performance criteria stated by manufacturer without defects, damage, or failure.

D. Regulatory Requirements:

1. Firestop Systems: Meet requirements of ASTM E814, UL 1479, or UL 2079 tested assemblies that provide a fire rating equal to that of construction being penetrated.
2. Proposed Firestop Materials and Methods: Conform to applicable governing codes having local jurisdiction.
3. Meet F and T ratings of ASTM E814 for a period equal to construction penetrated.
4. Underwriters Laboratories classified as fill, void, or cavity materials under UL 1479.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Show layout, profiles, and product components; include UL Systems Number on Shop Drawings and diagram of UL approved assembly.
2. Product Data: Include manufacturer's SPEC-DATA® product sheet for products selected for use.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Test Reports: Certified test reports showing compliance with specified performance characteristics and physical properties.
3. Certificates:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
   b. Certificate indicating installer qualifications.
   c. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
4. Special Guarantee documents specified below.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Experienced in performing Work of this section and specialized in the installation of work similar to that required for this Project.

B. Preinstallation Meetings: Conduct preinstallation meeting to identify where seals are required and verify Project requirements, substrate conditions, manufacturer's installation instructions, and manufacturer's warranty requirements.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Coordinate delivery of materials with scheduled installation date to allow minimum storage time at Project Site.

B. Deliver materials in manufacturer's original, unopened, undamaged containers with identification and UL listing mark intact.

C. Store materials under cover and protect from weather and damage in compliance with manufacturer's requirements.

D. Follow recommended procedures, precautions, or remedies described in Material Safety Data Sheets as applicable.

1.06 SEQUENCING AND SCHEDULING

A. Firestopping requirements may be created by mechanical and electrical portions of the Work:

1. Identify locations requiring firestopping.
2. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

1.07 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish firestop system products from a single manufacturer.

2.02 MANUFACTURERS

A. 3M Corp.; Firestopping Products.

B. Hilti Construction Chemicals; High Performance Firestop Systems.

C. International Protective Coatings Corp. (IPC); Flamesafe Firestop Products.

D. Isolatek International (Cafco); TPS.

E. Specified Technologies; Inc. (STI).

F. United States Gypsum Co. (USG); Firestop Systems and Thermafiber Safing Insulation.

2.03 MIXES

A. For those products requiring mixing prior to application, follow firestopping manufacturer's directions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other procedures needed to produce firestopping products of uniform quality with optimum performance characteristics for application indicated.

PART 3 EXECUTION

3.01 EXAMINATION

A. With manufacturer's representative, examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of firestopping. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Cleaning: Clean openings and joints immediately prior to installing firestopping in accordance with firestop manufacturer recommendations and the following requirements:

1. Remove foreign materials from surfaces of opening and joint substrates and from penetrating items that could interfere with adhesion of firestopping.
2. Clean opening and joint substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form release agents from concrete.

B. Priming: Prime substrates where recommended by firestopping manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent firestopping from contacting adjoining surfaces that will remain exposed upon completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestopping materials. Remove tape as soon as it is possible to do so without disturbing firestopping seal with substrates.

3.03 INSTALLATION

A. Manufacturer's Instructions: Follow manufacturer's instructions for installation of through-penetration systems selected for use.

1. Seal holes or voids made by penetrations for pipes, conduits and ducts through fire-rated floors, walls, and roofs and to ensure air and water resistant seals.
2. Receive Engineer's approval prior to installation of UL firestop systems that might hamper the performance of fire dampers as it pertains to duct work.

B. Fire Safing: Install, following manufacturer's instructions, to completely fill gaps between tops of fire-rated walls and floor or roof deck above, between edge of floors and walls, and other locations indicated on Drawings.

C. Meet Underwriters Laboratories and Factory Mutual requirements.

3.04 FIELD QUALITY CONTROL

A. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.

B. Keep areas of Work accessible until inspection by applicable code authorities.

C. Perform patching and repairing of firestopping caused by cutting or penetrating existing firestop systems.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, and training of installer's personnel in proper installation procedures.

3.06 PROTECTION

A. Protect installed product from contact with contaminating substances and from damage during construction.

END OF SECTION

SECTION 07 92 00
JOINT SEALANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C661, Standard Test Method for Indentation Hardness of Elastomeric Type Sealants by Means of a Durometer.
   b. C834, Standard Specification for Latex Sealants.
   c. C920, Standard Specification for Elastomeric Joint Sealants.
   d. C1193, Standard Guide for Use of Joint Sealants.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Surface preparation instructions. Indicate where each product is proposed to be used.
2. Samples: Material proposed for use showing color range available.

B. Informational Submittals:

1. Installation instructions.
2. Documentation showing applicator qualifications.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Special guarantee.

1.03 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum of 5 years' experience installing sealants in projects of similar scope.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Ambient Temperature: Between 40 degrees F and 80 degrees F (4 degrees C and 27 degrees C) when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

PART 2 PRODUCTS

2.01 SEALANT MATERIALS

A. Characteristics:

1. Uniform, homogeneous.
2. Free from lumps, skins, and coarse particles when mixed.
3. Nonstaining, nonbleeding.
4. Hardness of 15 minimum and 50 maximum, measured by ASTM C661 method.
5. Immersible may be substituted for nonimmersible.

B. Color: Unless specifically noted, match color of the principal wall material adjoining area of application.

C. Type 1—Silicone, Nonsag, Nonimmersible:

1. Silicone base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of withstanding movement up to 50 percent of joint width.
3. Manufacturers and Products:
   a. Dow Corning Corp.; No. 790.
   b. General Electric; Silpruf.
   c. BASF; Sonneborn, Omniseal-50.

D. Type 2—Multipart Polyurethane, Self-leveling, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. BASF; Sonneborn, SL-2.
   b. Pecora Corp.; Urexspan NR-200.
   c. Tremco; THC-900/901.
   d. Sika Chemical Corp.; Sikaflex 2c SL.

E. Type 3—Multipart Polyurethane, Nonsag, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. Pecora; DynaTrol II.
   b. Tremco; Dymeric 240.
   c. BASF; Sonneborn NP-2.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

F. Type 4—Multipart Polyurethane, Nonsag, Nonimmersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Manufacturers and Products:
   a. BASF; Sonneborn NP-2.
   b. Pecora Corp.; Dynatrol II.
   c. Tremco; Dymeric 240.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

G. Type 5—One-part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. BASF; Sonneborn, SL-1.
   b. Tremco; Vulkem 45.
   c. Sika Chemical Corp.; Sikaflex 1c SL.

H. Type 6—One-Part Polyurethane, Nonimmersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Manufacturers and Products:
   a. Pecora Corp.; Dynatrol 1 XL.
   b. Tremco; Dymonic.
   c. BASF; Sonneborn, NP-I.

I. Type 7—Multipart Polysulfide, Immersible:

1. Polysulfide base, two-component, chemical curing; ASTM C920, Type M, Grade P or NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. W. R. Meadows; Deck-O-Seal Gun Grade, two-part.
   b. BASF; Sonolastic, two-part Polysulfde.

J. Type 8—One-Part Polysulfide, Nonsag, Nonimmersible:

1. Polysulfide base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 12 1/2.
2. Capable of withstanding movement up to 20 percent of joint width.
3. Manufacturer and Product: W. R. Meadows; Deck-O-Seal, one-part.

K. Type 9—One-Part Acrylic Terpolymer, Nonsag, Nonimmersible:

1. Acrylic base, single-component, solvent curing; ASTM C834 nonsag.
2. Capable of withstanding movement up to 7.5 percent of joint width; Shore "A" hardness of 55 maximum.
3. Manufacturer and Product: Tremco; Mono 555.

L. Type 10—Sanitary Sealant:

1. Silicone sealant similar to Type 1, above, formulated to resist mold growth and repeated exposure to high humidity while retaining adhesion, flexibility, and color.
2. Manufacturers and Products:
   a. Dow Corning; 786.
   b. General Electric; Sanitary Sealant SCS1700.

M. Type 11—Fire Penetration Seal:

1. Manufacturers and Products:
   a. 3M Corp.; Fire Barrier Caulk CP25 and Putty 303.
   b. General Electric; Pensil Sealant or Foam.
   c. Unifrax Corporation; Fyre Putty.
   d. Hilti USA; CP 604.

N. Type 12—One-Part Polycarbonate, Immersible:

1. Polycarbonate base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturer and Product: Pro-Seal Products, Inc.; Pro-Seal 34.

O. Type 13—Tape Sealant:

1. Compressible polyurethane foam impregnated with polybutylene or polymer-modified asphalt.
2. Color: Black.

3. Size: 3/4 inch wide by length required by expanded thickness recommended by manufacturer for particular application.
4. Manufacturers and Products:
   a. Emseal Joint Systems, Ltd.; AST—High Acrylic.
   b. Dayton Superior; Polytite Standard.
   c. PARR Technologies; PARR Sealant EP-7212-T.

2.02 BACKUP MATERIAL

A. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.

B. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16 inch wide.

C. Manufacturers and Products:

1. Sonneborn; Sonolastic Closed-cell Backing Rod.
2. Tremco; Closed-cell Backing Rod.
3. Pecora Corporation; Green Rod.

2.03 ANCILLARY MATERIALS

A. Bond Breaker: Pressure sensitive tape as recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Noncorrosive and nonstaining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Primer: Nonstaining type recommended by sealant manufacturer to suit application.

2.04 PREFORMED SEALS

A. Preformed Compressible Joint Seals:

1. Widths Up to 5 Inches:
   a. BASF, Watson Bowman Acme Div.; Wabo Weatherseal II.
   b. Emseal Joint Systems Limited; Colorseal.
   c. LymTal International; Iso-flex Joint System.
2. Other Widths: Series or model recommended by seal manufacturer.

PART 3 EXECUTION

3.01 GENERAL

A. Use of more than one material for the same joint is not allowed unless approved by sealant manufacturer.

B. Install joint sealants in accordance with ASTM C1193.

C. Horizontal and Sloping Joints up to 1 Percent Maximum Slope: Use self-leveling (Grade P) joint sealant.

D. Steeper Sloped Joints, Vertical Joints, and Overhead Joints: Use nonsag (Grade NS) joint sealant.

E. Use joint sealant as required for the applicable application and as follows:

Joint Size	Sealant Type
Less than 1"	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, or 12
Less than 2"	1, 2, 3, 4, or 7
Over 2"	Follow manufacturer’s recommendation

3.02 PREPARATION

A. Verify that joint dimensions, and physical and environmental conditions, are acceptable to receive sealant.

B. Surfaces to be sealed shall be clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials.

1. Mask adjacent surfaces where necessary to maintain neat edge.
2. Starting of work will be construed as acceptance of subsurfaces.
3. Apply primer to dry surfaces as recommended by sealant manufacturer.

C. Verify joint shaping materials and release tapes are compatible with sealant.

D. Examine joint dimensions and size materials to achieve required width/depth ratios.

E. Follow manufacturer’s instructions for mixing multi-component products.

3.03 INSTALLATION

A. Use joint filler to achieve required joint depths, to allow sealants to perform intended function.

1. Install backup material as recommended by sealant manufacturer.
2. Where possible, provide full length sections without splices; minimize number of splices.
3. Tape sealant may be used as joint filler if approved by sealant manufacturer.

B. Use bond breaker where recommended by sealant manufacturer.

C. Seal joints around window, door and louver frames, expansion joints, control joints, and elsewhere as indicated.

D. Joint Sealant Materials: Follow manufacturer's recommendation and instructions, filling joint completely from back to top, without voids.

E. Joints: Tool slightly concave after sealant is installed.

1. When tooling white or light color sealant, use a water wet tool.
2. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.

F. Tape Sealant: Compress to 50 percent of expanded thickness and install in accordance with manufacturer's instructions.

3.04 PREFORMED SEALS

A. Prepare joint surfaces clean and dry, free from oil, rust, laitance, and other foreign material.

B. Construct joints straight and parallel to each other and at proper width and depth.

C. Apply joint sealant manufacturer's approved primer and adhesive in accordance with manufacturer's instructions.

D. Install seal in accordance with manufacturer's instructions.

3.05 CLEANING

A. Clean surfaces next to the sealed joints of smears or other soiling resultant of sealing application.

B. Replace damaged surfaces resulting from joint sealing or cleaning activities.

3.06 JOINT SEALANT SCHEDULE

A. This schedule lists the sealant types acceptable for each joint location. Use as few different sealant types as possible to meet the requirements of Project.

Joint Locations	Sealant Type(s)
Expansion/Contraction and Control Joints At:	
Concrete Walls (except water-holding and belowgrade portions of structures)	1, 3, 4, 5, 6, 7, 12
Concrete Floor Slabs (except for water-holding Structures)	2, 5
Slabs Subject to Vehicle and Pedestrian Traffic	2, 5
Masonry Walls	1, 3, 4, 5, 6, 7, 12, 13
Material Joints At:	
Metal Door, Window, and Louver Frames (Exterior)	1, 5, 6, 8, 12
Metal Door, Window, and Louver Frames (Interior)	1, 5, 6, 8, 9
Wall Penetrations (Exterior)	1, 5, 6, 8, 12
Wall Penetrations (Interior)	1, 5, 6, 8
Floor Penetrations	5, 6, 7
Roof Penetrations	5
Sheet Metal Flashings	5, 13
Precast/Prestressed Floor and Roof Panels	3, 7
Other Joints:	
Threshold Sealant Bed	5
Around Plumbing Fixtures	10
Openings Around Pipes, Conduits, and Ducts Through Fire-Rated Construction	11
Concrete Form Snap-Tie Holes	1, 4, 5

END OF SECTION

SECTION 08 11 16
ALUMINUM DOORS AND FRAMES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Incorporated (AA): Designation System for Aluminum Finishes.
2. American Architectural Manufacturers Association (AAMA): 605.2, Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions and Panels.
3. ASTM International (ASTM): B209/B209M, Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

1.02 SUBMITTALS

A. Action Submittals:

1. Applicable information for each type of door and frame, including:
   a. Frame conditions and complete anchorage details per project condition, supplemented by suitable schedules covering doors and frames.
   b. Glass and louver opening sizes and locations in doors.
   c. Any connections of door frames to structural steel framing concealed in frames.
   d. Submitted third party testing documentation or signed and sealed engineering of door assemblies to meet required developed positive and negative pressures.
   e. Location and field splice joints for frames too large to ship in one piece; indicate complete instructions for making field splices.
   f. Joints required to accommodate expansion joint movement.
   g. Relate to door numbers used in Contract Drawings.
   h. Include all hardware provided and/or installed by the door manufacturer.

B. Informational Submittals: Certificate of Compliance per Section 01 43 33, Manufacturer's Field Services (or alternately, test results or calculations), that assure items and its anchorages design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Properly identify each item with number used in Contract Drawings.

B. Store doors upright, in protected dry area, at least 1 inch off ground or floor and at least 1/4 inch between individual pieces.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers product must be able to meet developed positive and negative door assembly pressures for each exterior door assembly either by testing or engineering by a qualified Tennessee licensed engineer.

B. Manufacturers:

1. Cline Aluminum Doors, Inc., Bradenton, FL; Series 100BE.
2. United States Metals and Manufacturing Corp., South Bend, IN; D9 Series.

2.02 MATERIALS

A. Aluminum Frames:

1. Extruded from 6063-T5 aluminum alloy meeting ASTM B209.
2. Minimum Wall Thickness: 0.125 inch.
3. Mechanically fastened corners.
4. Reinforcements: 6061-T6 aluminum of 1/4-inch minimum thickness.
5. Size and Profile: Minimum 5 inches by 1-3/4 inches, with open or closed back and applied stop with integral weatherstripping.
6. Concealed fasteners or welding are preferred to through-the-face fasteners.

B. Flush Aluminum Doors: 6063-T5 extrusions and 5005-H14, smooth face sheets.

1. Minimum component thicknesses as follows:
   a. Base Sheets: 0.090 inch.
   b. Beveled Lock Rail Edge: 0.125 inch.
   c. Hinge Rail Edge: 0.190 inch.
   d. Internal Grid Sections: 0.080 inch.

2.03 MISCELLANEOUS ITEMS

A. Filler or Transom Panels: Furnish of same construction and finish as door if scheduled as flush panel.

B. Furnish manufacturer's standard core filler, anchors, fasteners, and other ancillary items.

C. Glazing: Accommodate glass of type and thickness indicated and as specified in Section 08 80 00, Glazing.

2.04 FACTORY FINISHING REQUIREMENTS

A. Aluminum Door and Frame Finish: Clear anodized AA-M12C22A41 or Color anodized AA-M12C22A42 or AA-M12C22A44 as selected by Engineer or Owner or as scheduled on Finish Schedule on project Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Frames:

1. Installation: Maintain scheduled dimensions, hold head level, and maintain jambs plumb and square.
2. Secure anchorages and connections to adjacent construction.
3. Wherever possible, leave frame spreader bars intact until frames are set perfectly square and plumb and anchors are securely attached.
4. Install following manufacturer's recommendations.

B. Doors:

1. Follow manufacturer's recommendations.
2. Hardware: In accordance with manufacturer's templates and instructions.
    a. Adjust operable parts for correct function.
    b. Remove hardware, with exception of prime coated items, tag, box, and reinstall after finish paint work is completed.

3.02 PROTECTION

A. Protect installed doors and frames against damage from other construction work.

3.03 SCHEDULES

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements, Door and Hardware Schedule **on** Drawings.

END OF SECTION

SECTION 08 14 00
WOOD DOORS AND STEEL FRAMES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

B. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A250.8, Recommended Specifications for Standard Steel Doors and Frames.
   b. A250.11, Recommended Erection Instructions for Steel Frames.
2. ASTM International (ASTM):
   a. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   b. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
   c. ASTM A 653/A 653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanealed) by the Hot-Dip Process
3. ASTM International (ASTM): E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
4. Window and Door Manufacturers Association (WDMA):
   a. Industry Standard I.S.1-A, Architectural Wood Flush Doors.
   b. Industry Standard I.S.6-A, Architectural Wood Stile and Rail Doors.
5. Underwriters Laboratories Inc. (UL): Building Materials Directory.
6. Warnock Hersey Certification Listings.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Prepare specifically for this Project, indicating location and size of each door, veneer species, type and characteristics, elevation of each kind of door, details of construction, location and extent of hardware blocking, fire ratings, factory finishing, if any, glass and glazing, and other pertinent data.
   a. For factory-premachined doors, also indicate dimensions and locations of cutouts for finish hardware and cutouts for light and louver openings.
   b. Use same reference numbers for door openings and details as Contract Drawings.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Manufacturer's instructions for care and handling.
3. Maintenance instructions for sealing door edges.
4. Certificate of Compliance per Section 01 43 33, Manufacturer's Field Services (or alternately, test results or calculations), to document that item and anchorage design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Deliver doors to Job Site after moisture-producing construction operations are complete and building has reached average prevailing relative humidity of locality.
2. Deliver doors clearly marked with manufacturer's name, brand name, size, thickness, and identifying symbol.
3. Seal edges of doors before delivery to Job Site.

B. Storage:

1. Store doors in area where there will be no variation greater than plus or minus 5 percent in heat and humidity.
2. Stack flat on wood blocking, laid 12 inches from ends and across center.
3. Under bottom door and over top of stack provide plywood or corrugated cardboard to protect door surface.

C. Handling:

1. Handle with clean gloves.
2. Do not drag doors across one another or across other surfaces.

1.04 SPECIAL GUARANTEE

A. Provide as special guarantee, manufacturer's extended guarantee or warranty, with Owner named in writing as beneficiary. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of flush doors specified in this Specification section found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

B. Conditions: Free of warp more than 1/4 inch in plane of door and no delamination of veneers.

PART 2 PRODUCTS

2.01 FLUSH WOOD DOORS

A. Solid Core Wood Doors:

1. Premium grade, five-ply.
2. Staved wood core or particleboard core.
3. Type I glue.
4. Thickness: 1-3/4 inches.
5. Faces veneers and matching vertical edges of plain sliced red oak.
6. Doors to be factory finished stain with satin gloss Enviroclad UV finish or equal.
7. Manufacturer: Marshfield Door System, Inc. or approved equal.

B. Door Louvers: As specified and scheduled in Section 08 90 00, Louvers and Vents.

C. Glass Stops:

1. Nonfire-Rated Doors: Hardwoodto match door face.
2. Fire-Rated Doors: Metal with veneer cover to match door face.

D. Fire-Rated Doors:

1. Solid core wood doors that are listed in UL Building Materials Directory or Warnock Hersey Certification Listings.
2. Bear label for rating scheduled.

2.02 FABRICATION OF FLUSH WOOD DOORS

A. Manufacture in accordance with WDMA Industry Standard I.S.1-A.

B. Wood Louvers: Factory install into prepared openings.

C. Glass Stops: Factory install, loose tacked for easy removal.

D. Moldings: Factory install in configuration indicated.

E. Prefitting and Premachining of Doors: At Contractor's option.

1. Within tolerances specified herein.
2. Coordinate with Finish Hardware Schedule and door frames.

2.03 STEEL DOOR FRAMES

A. Wood doors are to be installed in painted steel frames.

B. Frames are to be hot dipped zinc coated steel that complies with ASTM designations A924 A60, 16 ga.

C. Zinc-coated steel conforming to ASTM A 653/A 653M, CS, Type B.

D. All frames are to have back welded face seams only at the frame corner or intersections. Grind and dress smooth the weld area. Apply a factory baked-on zinc rich primer over the grinding area and finish with a matching prime paint which must be compatible with any field applied paint .

E. Provide steel frames the size and design as shown on the drawing's Door and Hardware Schedule.

F. Acceptable Manufacturers:

1. Steelcraft Manufacturing; F series.
2. Curries Company: M series.
3. Ceco Door Products: SF Series.

G. Fabrication:

1. Minimum height of stops; 5/8 in. (15.8 mm).
2. All finished work to be strong and rigid and neat in appearance, square, true and free of defects.

3. Hardware reinforcements are to be in accordance with minimum standard gauges as listed in SDI-100.
4. Frames shall be mortised, reinforced, drilled and append at the factory for template mortised hardware only. Hinge reinforcement to be 7-gauge steel.

H. Anchors:

1. Anchors for masonry are to be wire type unless otherwise approved.
2. Provide three silencers on a single door and two silencers for double door installations.
3. All frames that are welded are to be supplied with a steel spreader which temporarily braces frame for shipping and handling. Anchores for stud partitions are to steel of a suitable design , not less than 18 gauge.

2.04 SOUND-RESISTANT DOORS

A. Solid core doors with minimum Sound Transmission Class (STC) of 35 decibels or better when tested in accordance with ASTM E90 for offices only.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify door frames are of type required for door and are installed as required for proper installation of doors.

B. Do not install doors in frames that would hinder operation of doors.

3.02 INSTALLATION- FRAMES

A. Floor Anchors:

1. For welded and knocked-down frame product, weld floor anchors inside jambs.
2. Thickness of floor anchors; same as frame, minimum.
Where specified or scheduled, provide welded adjustable floor anchors with not less than 2 in. (50.8 mm) height adjustment. For applications that do not permit the use of a floor anchor, substitute an additional jamb anchor at a location not to exceed 8 in. (204 mm) from the base of the jamb.

3. Jamb Anchors:
   a. Provide frame product with anchorage appropriate to frame and wall construction.
   b. Masonry Type Provide steel adjustable jamb anchors of the strap and stirrup or T-strap type not less than 0.053 in. (1.34 mm) thickness or 0.156 in. (4 mm) diameter wire type, for frame product to be installed in new masonry walls.

B. Straps; 2 inches by 10 inches (50 mm x 254 mm) in size minimum, corrugated and/or perforated. Place jamb anchors at a maximum of 18 inches (457 mm) from top and bottom of openings. Minimum number of anchors, spaced at maximum of 32 in. (813 mm) on center, provided on each jamb based on the over-all frame height:

C. Install all hardware scheduled for door assembly. See Door Hardware Specification 08 71 00, Door Hardware.

D. Fit doors for width by planning; for height by sawing.

E. Tolerances:

1. From Bottom to Floor Covering: 1/2 inch.
2. From Bottom to Top of Threshold: 1/4 inch.
3. Maximum From Top: 1/8 inch.
4. Bevel Lock and Hinge Edges: 1/8 inch in 2 inches.
5. Clearance of Meeting Stiles of Pairs of Doors: 1/8 inch.

F. Seal Job Site cut surfaces with two coats of door manufacturer's standard sealer before final hanging of doors.

3.03 ADJUST AND CLEAN

A. Replace or rehang doors that are hinge-bound and do not swing or operate freely.

B. Replace prefinished doors damaged during installation.

C. Refinish or replace job-finished doors damaged during installation.

3.04 SCHEDULE

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements, see Door and Hardware Schedule on Drawings.

END OF SECTION

SECTION 08 33 23
OVERHEAD COILING DOORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   b. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   c. A924/A924M, Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
   d. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   e. B221M, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric).
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
2. Intertek Testing Services (Warnock Hersey Listed) (WH): Certification Listings.
3. National Association of Metal Manufacturers (NAAMM).
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   c. MG 1, Motors and Generators.
5. National Fire Protection Association (NFPA):
   a. 80, Standard for Fire Doors and Other Opening Protectives.
   b. 252, Standard Methods of Fire Tests of Door Assemblies.
6. Underwriters Laboratories Inc. (UL):
   a. Building Materials Directory.
   b. 10B, Standard Safety for Fire Tests of Door Assemblies.
   c. 325, Standard Safety for Door, Drapery, Gate, Louver, and Window Operators and Systems.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Indicate pertinent dimensioning, anchorage methods, hardware locations, and installation details.
2. Product Data: General construction, component connections and details.
3. Samples: Submit two door slats, 12 by 12 inch in size illustrating shape, color and finish texture.

B. Informational Submittals:

1. Third party testing documentation or manufacturer’s literature qualifying door model as meeting required developed wind pressures.
2. Manufacturer's Instructions: Indicate installation sequence and procedures, and adjustment and alignment procedures.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data, include lubrication requirements and frequency, and periodic adjustments required.
4. Seismic Anchorage and Bracing:
   a. Drawings and product data as required by Section 01 88 15, Anchorage and Bracing.
   b. Calculations as required by Section 01 88 15, Anchorage and Bracing.
   c. Installer’s factory authorization.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Company specializing in manufacturing products specified in this section with minimum 3 years documented experience.
2. Installer: Company specializing in performing work of this section with minimum 5 years documented experience approved by manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. The Cookson Co.; FCWI or FMWI.
2. Other Manufacturers:
   a. Cornell Iron Works; MFW-6F.
   b. Overhead Door Corp. UFN Series 625.

2.02 GENERAL

A. Wind Loads: Design door assembly to withstand wind/suction load indicated on the Drawings, with maximum deflection of 1/120, and without damage to door or assembly components.

B. Operation: Design door assembly to operate for not less than 10,000 cycles and 10 cycles per day.

2.03 COMPONENTS

A. Curtain: Conform to the following:

1. Aluminum Slats: Interlocking, minimum 0.040 inch (1 mm) thick of ASTM B221M aluminum alloy Type 6063.
2. Type: Sandwich slat construction with manufacturer's standard insulated core with maximum U-value of 0.16 and backing to match face slat, thermally separated from face slat.
3. Nominal Slat Size: 3 inches wide by required length.
4. Slat Ends: Alternate slats fitted with end locks to act as wearing surface in guides and to prevent lateral movement.
5. Curtain Bottom: Fitted with aluminum angles, channels, or hollow extrusion to provide reinforcement and positive contact with floor in closed position.

B. Guides: Minimum 0.1875 inch thick; aluminum angles.

C. Roller Shaft Counterbalance: Steel pipe and helical steel spring system, capable of producing torque sufficient to ensure smooth operation of curtain from any position and capable of holding position at mid-travel; with adjustable spring tension.

D. Hood Enclosure and Fascia: Square shape, minimum 0.040-inch thick aluminum; internally reinforced to maintain rigidity and shape.

E. Hardware:

1. Locks: Furnish locks to allow doors to be secured.
   a. Manual Doors: Manufacturer's standard cylinder dead lock on inside at door jamb, key operated from interior.
2. Weatherstripping Exterior Assemblies: Moisture and rot proof, resilient type for complete weathertight installation.
   a. Rubber, neoprene, or vinyl water seal at hood to prevent airflow around coil on exterior doors.
   b. Weather seal sealing strip on guide to close space between guide and curtain on exterior doors.

F. Manual Operation: Manual hand chain lift.

2.04 FINISHES

A. Curtain Slats: Aluminum, bronze anodized.

B. Aluminum Guides and Hood Enclosure: Aluminum, bronze anodized.

2.05 SOURCE QUALITY CONTROL

A. Apply label from agency approved by authority having jurisdiction to identify each foam plastic insulation board.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify opening sizes, tolerances and conditions are acceptable.

3.02 INSTALLATION

A. Use anchorage devices to securely fasten assembly to wall construction and building framing without distortion or stress.

B. Securely and rigidly brace components suspended from structure. Secure guides to structural members only.

C. Fit and align assembly including hardware; level and plumb, to provide smooth operation.

D. Coordinate installation of sealants and backing materials at frame perimeter as specified in Section 07 92 00, Joint Sealants.

E. Install perimeter trim and closures.

3.03 TOLERANCES

A. Maintain dimensional tolerances and alignment with adjacent Work.

B. Maximum Variation from Plumb: 1/16 inch.

C. Maximum Variation from Level: 1/16 inch.

D. Longitudinal or Diagonal Warp: Plus or minus 1/8 inch per 10 feet (3 mm per 3 m) straight edge.

3.04 ADJUSTING

A. Adjust door, hardware and operating assemblies for smooth and noiseless operation.

3.05 CLEANING

A. Leave door and components clean.

B. Remove labels and visible markings.

END OF SECTION

SECTION 08 51 13
ALUMINUM WINDOWS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Incorporated (AA): Designation System for Aluminum Finishes.
2. American Architectural Manufacturers Association (AAMA):
   a. 101, Voluntary Specifications for Aluminum and Poly(Vinyl Chloride) (PVC) Prime Windows and Glass Doors.
   b. 605.2, Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions and Panels.
   c. 606.1, Voluntary Guide Specifications and Inspection Methods for Integral Color Anodic Finishes for Architectural Aluminum.
   d. 701, Combined Voluntary Specification for Pile Weather Strip.
   e. 800, Voluntary Specification and Test Methods for Sealants.
3. ASTM International (ASTM):
   a. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.
   c. B456, Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium.
   d. B633, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
   e. C509, Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material.
   f. C864, Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers.
   g. C1036, Standard Specification for Flat Glass.
   h. D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   i. D3656, Standard Specification for Insect Screening and Louver Cloth Woven from Vinyl-Coated Glass Yarns.
   j. E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.
   k. E283, Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
   l. E330, Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference.

m. E331, Standard Test Method for Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference.
n. E2190, Standard Specification for Insulating Glass Unit Performance and Evaluation.
o. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

4. Glass Association of North America (GANA): Glazing Manual.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Large scale details and layout of windows, operators, anchorages, and adjoining construction with all materials indicated accurately to scale.
   b. Manufacturer's literature including brochures or catalogs, specifications, instructions, and standard details illustrating products proposed for use and other window products available.
2. Samples: Finish on aluminum in sets of two, indicating light and dark extremes, to be used in evaluating products furnished.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance.
2. Reports of factory quality control tests.

1.03 QUALITY ASSURANCE

A. All Units: Meet construction and testing requirements of AAMA 101 and carry the quality certified label of AAMA.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store window units in vertical upright position and off the ground on dunnage, preferably inside a building.

B. Protect units from weather, abuse, defacement, and damage.

C. Store units inside in areas free of dust and corrosive fumes, as close as possible to point of installation.

D. Prevent contaminants from contacting aluminum.

E. Keep water away from stored units and assemblies.

F. Handle units according to recommendations of AAMA.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this Specification section found defective during period of 10 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Aluminum: Proper alloy and temper to meet specified requirements.

B. Hardware: Corrosion-resistant and compatible with aluminum; suitable for intended use and the same as used on the tested units.

C. Anchors and Fasteners:

1. Exposed: Aluminum, Type 304 stainless steel, or ASTM B456 nickel-plated brass.
2. Concealed: Aluminum, cadmium-plated steel, ASTM B633 or ASTM A123 zinc-plated steel, or Type 304 stainless steel.
3. Concealed anchors may be of carbon steel, painted after fabrication with zinc chromate primer.
4. Other Fasteners and Components: Carbon steel or ASTM B456 Nickel plus Chromium plated.

D. Sealants:

1. AAMA 800 to seal metal to metal, nonworking joints.
2. Color to be compatible with adjacent materials.

E. Weatherstripping: High-quality materials capable of meeting environmental exposure and performance requirements.

1. Pile Weatherstrip: AAMA 701.
2. Closed Cell Elastomer: ASTM C509.
3. Dense Elastomer: ASTM C864.

F. Glass and Glazing: As Specified in Section 08 80 00, Glazing.

2.02 FABRICATION

A. Fabricate and assemble frame, sash, and ventilator members into windows and window systems in accordance with reviewed Shop Drawings, and as required by AAMA 101.

B. Mechanical fasteners, welded components, and hardware items shall not bridge thermal barriers unless the window units tested also have thermal bridges.

C. Sealing Insulating Glass Units: Designed so that water entering space around unit will drain and not remain in contact with edge seal of the glass.

D. Glazing Beads:

1. Sloped and coped to uniformly tight hairline joints at corners.
2. Material may be prefinished.

2.03 FINISH

A. Finish components after fabrication, except those that may be prefinished as specified.

B. Exposed framing members shall be free of scratches and other surface blemishes.

C. Anodic Coating: Conform to AAMA 606.1, dark bronze.

2.04 ANCILLARY MATERIALS

A. Isolation Tape:

1. Manufacturers and Products:
   a. Tremco; 440.
   b. 3M; EC1202.
   c. Presstite; 579.6.

B. Isolation Paint: Bituminous coating conforming to ASTM D1187.

2.05 FIXED WINDOWS

A. Meet requirements of AAMA 101 Designation F-C20.

B. Provide polyvinyl chloride thermal break separator between inside and outside for all frames.

2.06 SOURCE QUALITY CONTROL

A. Tests:

1. Resistance to Air Infiltration: No greater than 0.06 cfm per square foot of fixed area, as tested in accordance with ASTM E283.
2. Resistance to Water Infiltration: No leakage in frame at test pressure difference of 8 psf, as tested in accordance with ASTM E331.
3. Resistance to Uniform Loading: When tested under load of 20 psf, in accordance with ASTM E330:
   a. Maximum Deflection: No greater than 1/175 times span for any member.
   b. When load is removed, no evidence of permanent deformation or damage.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify dimensions by taking measurements at the Site.

B. Verify that openings are within allowable dimensional tolerances, are plumb, level, clean, and provide a solid anchoring surface.

C. Verify conformance with Shop Drawings and that dimensions and conditions are correct before installing windows.

3.02 INSTALLATION

A. Window and Window Components:

1. Plumb and align window faces in a single plane for each wall plane.
2. Erect windows and materials square and true and in proper alignment with other work, anchored to maintain position when subjected to normal thermal and building movement and wind loads as shown on structural drawings.
3. Install in accordance with manufacturer’s instructions.
4. Installation shall be weathertight as specified under Article Source Quality Control.

B. Coat aluminum surfaces in contact with concrete, cement plaster, or stucco with isolation paint, sealant, or isolation tape cut to neat line.

3.03 GLAZING

A. Glass may be factory or field installed.

B. Install in accordance with Section 08 80 00, Glazing and glass manufacturer's instructions.

3.04 ADJUSTING AND CLEANING

A. Remove protective materials and clean windows with potable water, or water with household soap or detergent.

B. Inspect and readjust glazed ventilators as necessary for free operation at completion.

C. Adjust windows for proper operation after installing.

D. Lubricate hardware and movable units.

E. Leave windows in closed position after adjusting and cleaning.

3.05 PROTECTION

A. Protect installed window units from materials that could cause damage, such as lime, mortar, runoff from concrete and copper, careless handling of tools, weld splatter, acids, roofing asphalt, solvents, and abrasive cleaners.

3.06 SCHEDULE

A. For window types, sizes, glass, and other requirements, see Window Schedule on Drawings.

END OF SECTION

SECTION 08 71 00
DOOR HARDWARE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Builders Hardware Manufacturer's Association (BHMA):
   a. A156.1, Butts and Hinges.
   b. A156.2, Bored and Preassembled Locks and Latches.
   c. A156.3, Exit Devices.
   d. A156.4, Door Controls - Closers.
   e. A156.13, Mortise Locks & Latches.
   f. A156.16, Auxiliary Hardware.
   g. A156.18, Materials and Finishes.
2. International Code Council (ICC): A117.1, Accessible and Usable Buildings and Facilities.
3. Underwriters Laboratories, Inc. (UL): Fire Protection Equipment List.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Manufacturer's literature for each item of finish hardware required herein, clearly marked.
   b. Finish Hardware Schedule: Furnish complete and detailed schedule, show product items, numbers, and finishes for hardware for each separate opening.
   c. Special Tools: Provide listing and description of usage.

B. Informational Submittals:

1. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
2. Manufacturer's Field Service Report.
3. Certification of Hardware Consultant.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.03 QUALITY ASSURANCE

A. Qualifications of Supplier: Recognized supplier of architectural finish hardware, with warehousing facilities, who has been furnishing hardware in vicinity of Project for not less than 5 years, and who is, or who employs, architectural hardware consultant.

B. Qualifications of Architectural Hardware Consultant (AHC): Certified by Door and Hardware Institute.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Before delivery, clearly identify and tag each item of hardware with respect to specified description and location of installation.

B. Provide secure storage for finish hardware until installation is made.

1.05 EXTRA MATERIALS

A. Special Tools: Two sets for installation and maintenance of hardware.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide end products of one manufacturer for each product in order to achieve standardization for appearance, maintenance, and replacement.

B. Finishes: BHMA A156.18.

2.02 FASTENERS

A. Stainless steel.

2.03 BUTT HINGES

A. BHMA A156.1.

B. Quantity per Door Leaf (Minimum):

Door Height	Hinges
Up to 5'-0"	1 pair
5'-1" to 7'-7"	1-1/2 pair
7'-8" to 10'-0"	2 pairs
10'-1" to 12'-6"	2-1/2 pairs

C. Hinge Height (Minimum):

Door Width	Hinge Height
Up to 3'-0"	4-1/2"
3'-1" to 4'-0"	5"
Over 4'-0"	6"

D. Width: Minimum for clearance of trim and 180-degree swing.

E. Exterior Hinges: Nonremovable pin.

F. Joint Tolerance: 0.012 inch maximum, gauged in CLOSED position.

G. Finish: Satin stainless steel No. 630.

H. Types and Manufacturers:

No.	Type Description	Stanley	Mc-Kinney	Lawrence	BHMA
H1	Regular weight, two ball-races, full mortise, stainless steel	FBB191-32D	TB2314	BB4101-32D	A5112

2.04 LOCKS AND LATCH SETS

A. Mortise Locks: BHMA A156.13, Series 1000, Grade 1.

1. Materials: Brass or stainless steel.
2. Trim: Wrought or forged lever handles and roses.
3. Core Cylinders: Interchangeable, removable; minimum of six pins.
4. Bolt Throw: 5/8 inch minimum.
5. Lever Backset: 2-3/4 inches.
6. Manufacturers and Products:
   a. Sargent; LNJ.
   b. Schlage; 03.
   c. Best; 3H Fairbanks.

B. Tactile Warning: Knurl knob backs and lever handles for touch identification; ICC A117.1, Section 4.29.3.

C. Finish: Satin stainless steel No. 630.

D. Types and Manufacturers:

No.	Type Description	Best	Sargent	Schlage	BHMA
L1	Mortise entrance lock with lever handle	45H7TA3H	8245-LNJ	L9456P-03	F12, F13
L3	Mortise latch with lever handle	45H0N3H	8215-LNJ	L9010-03	F01
L5	Mortise utility room lock with lever handle	45H7D3H	8204-LNJ	L9080-03	F07
L8	Mortise privacy lock with lever handle	45H7L3H	8265-LNJ	L9040-03	F19, F22
L16	Lock by exit device manufacturer; furnish cylinders for keying to other locks as required				

E. Keying:

1. Lock Cylinders: Operate by master key system that allows for future expansion.
2. Keylocks: As directed by Owner.
3. Keys: Two per lock; tag with schedule information.
4. Master Keys: Four; send by registered mail to Owner.

2.05 CONSTRUCTION KEY SYSTEM

A. Removable construction core system for locks.

B. See Article Manufacturer’s Services under Part 3, Execution.

2.06 EXIT DEVICES

A. BHMA A156.3.

B. Furnish fire exit devices and mullions at fire-rated doors.

C. Trim:

1. Knobs: Sargent PRK; Von Duprin K.
2. Levers: Sargent ETJ; Von Duprin 03.

D. Finish:

1. Exit Device: Satin chromium-plated No. 626.

E. Types and Manufacturers:

No.	Type Description	Sargent	VonDuprin	BHMA
X1	Rim type; active leaf for pairs	8813ETJ	99L	Type 1 08

2.07 CLOSERS

A. BHMA A156.4.

B. Size closers in accordance with manufacturer's standards. Mount regular arm closers on pull side of doors. Mount parallel arm closers on push side of doors. On pair of doors provide closer on active leaf only, unless noted otherwise.

C. Finish: Manufacturer's powder coated finish with special rust inhibiting (SRI) pretreatment. Color selected by Engineer.

D. Types and Manufacturers:

No.	Type/Description	LCN	Sargent	BHMA
C1	Regular arm	4010 Series	351 Series	C02011
C2	Parallel arm	4110 Series	351-P Series	C02021
C6	Parallel arm with integral stop and hold-open	4110H Cush-N-Stop Series	351-PSH Series	C02061

2.08 STOPS AND HOLDERS

A. BHMA A156.16.

B. Machine Screws: In threaded anchors at concrete or masonry.

C. Self-Tapping Screws: At stud partitions, wood, or metal mountings.

D. Metal Risers: For mounting at carpet floors.

E. Finish: Satin chromium-plated No. 626.

F. Types and Manufacturers for each Leaf:

No.	Type Description	BBW or GJ	Baldwin	BHMA
S2	Wall bumper	WC9T	4032	L02251

2.09 BOLTS

A. BHMA A156.16.

B. Finish: Bright nickel No. 645.

C. Types and Manufacturers:

No.	Type/Description	Stanley	Lawrence	BHMA
B2	Top and bottom surface bolts	CD4060	283	(L04151)

2.10 THRESHOLDS

A. Thresholds: One-piece full width of opening; extend beyond jamb where indicated.

B. Provide with stainless steel machine screws in threaded expansion anchors at concrete.

C. Finish: Dark bronze anodized aluminum, unless indicated otherwise.

D. Types and Manufacturers:

No.	Type Description	Pemko	Reese
T2	Saddle (serrated, 4" x 1/4")	270D	S404D
T6	Panic exit saddle	2005DV	S483DV

2.11 WEATHERSTRIP

A. Finish: Dark bronze anodized aluminum, unless indicated otherwise.

B. Seal Types and Manufacturers:

No.	Type Description	Pemko	Reese
W1	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door shoe	222DV	DB596DF
	Rain drip	346D	R201D

No.	Type Description	Pemko	Reese
W2	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door shoe	222DV	DB596DF

2.12 MISCELLANEOUS ITEMS

A. Provide as indicated in Door and Hardware Schedule:

M1	Nameplate as specified in Section 10 14 00, Signage, in text noted in Door and Hardware Schedule
M3	Barrier-free pictorial symbol, 6 inch by 6 inch, as specified in Section 10 14 00, Signage, in text noted in Door and Hardware Schedule

2.13 SILENCERS

A. Ives, Glynn-Johnson.

B. At metal frame of each hinged door that does not have seals scheduled.

C. Three at single leaves and two at pairs.

2.14 TEMPLATES

A. Fabricate to template hardware applied to metal doors and frames.

B. Ensure that required templates are furnished to various manufacturers for fabrication purposes.

C. Templates: Make available not more than 10 days after receipt of approved Hardware Schedule.

2.15 EXIT AND FIRE DOORS

A. Exit Doors: Always openable from inside by simple turn of lever handle or push on panic bar without use of key or any special knowledge or effort, to include each leaf of door pairs.

B. Hardware for Fire Doors: Underwriters Laboratories Inc., Fire Protection Equipment List.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Make Work neat and secure, develop full strength of components, and provide proper function.

C. Prevent marring, scratching, or otherwise damaging adjacent finishes during hardware installation.

D. Latchbolts:

1. Install to engage in strikes automatically, whether activated by closers or manually.
2. In no case shall additional manual pressure be required to engage latchbolt in strike.

E. Stops and Holders: Set to allow doors to open as far as possible.

F. Wall Mounted Hardware: Install over solid structural backing or solid blocking in hollow walls.

G. Thresholds:

1. Cope ends neatly to profile of jamb.
2. Set in sealant and seal ends to jambs.

H. Hardware: Adjust for easy, noise-free operation.

I. Replace damaged hardware items.

3.02 MOUNTING DIMENSIONS

A. Standard Door Hardware Locations: As recommended and published by Door and Hardware Institute, except as noted or detailed otherwise.

B. Door Silencers: Install 3 inches from top and bottom of jamb and 1 inch above strike at single doors, and 3 inches from edges of doors in head for pairs of doors.

3.03 MANUFACTURER'S SERVICES

A. Deliver permanent lock cores to Site.

B. Remove temporary construction cores and insert permanent cores.

C. Inspect each lock set to ensure permanent cores are operating satisfactorily.

D. Deliver to Owner change and control keys for permanent system.

E. Return temporary construction cores to manufacturer.

F. Furnish manufacturer's representative for the following services at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-days for installation assistance, inspection, and Manufacturer's Certificate of Proper Installation.
2. 1 person-days for functional and performance testing.

3.04 PROTECTION

A. Cover and protect exposed surfaces of hardware during installation and until Substantial Completion.

B. Fit, dismantle, and reinstall finish hardware as required for finish painting work.

C. Protect and prevent staining of hardware during construction in accordance with manufacturer's recommendations.

D. Remove protective measures and permanent lock cylinders installed prior to final cleaning.

3.05 DOOR AND HARDWARE SCHEDULE

A. Door and Hardware Schedule on Drawings is guide to functional requirements of each opening.

B. Provide finish hardware as scheduled. Sizes omitted shall be as recommended by manufacturer.

3.06 HARDWARE SETS

HDW-1:	Item	Type
	3 Pair butts	H1
	1 Exit devices (rim type) active leaf with cylinder for keying to other locks as required	X1
	1 Lock	L16
	Top and bottom flush bolts inactive leaf	B2
	2 Closers	C6

HDW-1:	Item	Type
	1 Threshold	T6
	1 Set weatherstrip	W1
HDW-2:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Exit devices (rim type) with cylinder for keying to other locks as required	X1
	1 Lock	L16
	1 Closer	C2
	1 Threshold	T2
	1 Set weatherstrip	W1
HDW-3:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Lock	L1
	1 Closer	C2
	1 Threshold	T2
	1 Set weatherstrip	W1
HDW-4:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Latch	L3
	1 Closer	C1 or C2
	1 stop	S2
HDW-5:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Lock	L5
	1 Closer	C1 or C2
	1 stop	S2
HDW-6:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Privacy lock	L8
	1 Closer	C1 or C2
	1 Stop	S2

END OF SECTION

SECTION 08 80 00
GLAZING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): Z97.1, Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Test.
2. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
3. ASTM International (ASTM):
    a. C509, Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material.
    b. C864, Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers.
    c. C920, Standard Specification for Elastomeric Joint Sealants.
    d. C1036, Standard Specification for Flat Glass.
    e. C1048, Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass.
    f. C1115, Standard Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories.
    g. C1172, Standard Specification for Laminated Architectural Flat Glass.
    h. C1193, Standard Guide for Use of Joint Sealants.
    i. C1376, Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass.
    j. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
    k. D2843, Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics.
    l. D4802, Standard Specification for Poly(Methyl Methacrylate) Acrylic Plastic Sheet.
    m. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    n. E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
    o. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.
    p. E1300, Standard Practice for Determining Load Resistance of Glass in Buildings.

q. E1425, Standard Practice for Determining the Acoustical Performance of Windows, Doors, Skylight, and Glazed Wall Systems.
r. E1886, Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.
s. E1996, Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.
t. E2190, Standard Specification for Insulating Glass Unit Performance and Evaluation.

4. Consumer Product Safety Commission (CPSC) Code of Federal Regulations (CFR): 16 CFR 1201, Safety Standard for Architectural Glazing Materials.
5. Glass Association of North America (GANA):
   a. Glazing Manual.
   b. Sealant Manual.
6. National Fenestration Rating Council Incorporated (NFRC):
   a. 100, Procedure for Determining Fenestration Product U-Factors.
   b. 200, Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence.
   c. 300, Standard Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems.
7. National Fire Protection Association (NFPA):
   a. 80, Safety Standard for Fire Doors and Other Opening Protectives.
   b. 252, Safety Standard Methods of Fire Tests of Door Assemblies.
   c. 257, Safety Standard on Fire Test for Window and Glass Block Assemblies.
8. South Coast Air Quality Management District: SCAQMD Rule 1168 - Adhesive and Sealant Applications.
9. Underwriters Laboratories, Inc. (UL):
   a. Building Materials Directory.
   b. 10C, Standard for Safety for Positive Pressure Fire Tests of Door Assemblies.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete schedule of glass and glazing material to be used for each purpose.
   b. Indicate sizes, layout, thicknesses, and loading conditions for glass.

2. Product Data:
   a. Catalog cuts of glazing materials with inclusion of glass edge cutting procedures.
   b. Glass: Provide structural, physical, and thermal and solar optical performance characteristics, size limitations, special handling or installation requirements.
   c. Glazing Sealants, Compounds, and Accessories: Provide chemical, functional, and environmental characteristics, limitations, special application requirements. Identify available colors where exposed.
3. Samples:
   a. Glass: Two samples 12 by 12 inch in size, illustrating each glass units, coloration and sealant design.

B. Informational Submittals:

1. Design calculations for glass thicknesses. Signed and sealed by professional engineer registered in state of Project.
2. Manufacturer's Certificate of Compliance for each type of glazing, in accordance with Section 01 61 00, Common Product Requirements.
3. Details and methods of glazing for each type of glazing condition; include manufacturer's recommendations for setting, sealing materials, and installing each type of glazing.
4. Documentation declaring compatibility and adhesion test reports from sealant manufacturer indicating that glazing materials were tested for compatibility and adhesion with glazing sealants and other glazing materials.
5. Documentation of glazer's previous experience and manufacturer's approval.

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing Work of this section with minimum 3 years' documented experience approved by manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage:

1. Support cases on both sides when stored vertically.
2. After unpacking, place interleaving protection between lites.
3. Keep glass and interleaving dry by storing inside where temperatures are above dewpoint, or if outside storage is necessary, cover glass interleaving with opaque tarpaulins or plastic and inspect periodically. Wet interleaving can stain glass.
4. Avoid exposing stored glass to direct sunlight.

B. Handling:

1. Stack individual lites on edge and lean them against sturdy uprights at a slope of 5 degrees to 7 degrees from vertical.
2. Cushion bottom edges with soft, firm pads free of dirt, grit, glass chips, or other foreign material.
3. Do not rotate or cartwheel insulating glass units over their corners. Use turning device such as a rolling block if units must be rotated.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this specification section found defective during a period of 10 years for vertical application insulating glass after date of Substantial Completion. Guarantee to cover deterioration because of normal conditions of use and not because of handling installing and cleaning practices performed contrary to glass manufacturer's published instructions. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

A. Single Source Fabrication Responsibility: Fabrication processes including Low-E and reflective coatings, insulating, laminating, silkscreen, and tempering, shall be fabricated by a single fabricator.

B. Performance/Design Criteria:

1. Provide glass and glazing materials for continuity of building enclosure vapor retarder and air barrier:
   a. To utilize inner pane of multiple pane sealed units for continuity of air barrier and vapor retarder seal.
   b. To maintain continuous air barrier and vapor retarder throughout glazed assembly from glass pane to heel bead of glazing sealant.
2. Glass Thickness: Select minimum thickness in accordance with ASTM E1300 to resist specified design loads with the following maximum probability of breakage:
   a. Vertical Glass: Eight lites per 1000 for wind loads with 60 seconds maximum load duration.
   b. Minimum Thickness: 1/4 inch (6 mm) for exterior glass.

C. Structural Design: Design in accordance with the International Building Code for most critical combination of wind, snow, seismic, and dead loads.

D. Wind Loads: Design and size glass to withstand positive and negative wind loads acting normal to plane of wall, including increased loads at building corners.

1. Design wind pressures for components and cladding as shown on the structural drawings.
2. Exterior Glass Deflection: Maximum of 1/175 of glass edge length or 3/4 inch (19 mm), whichever is less with full recovery of glazing materials.
3. Interior Glass Deflection: Maximum differential deflection for two adjacent unsupported edges when 50 plf (730 N/m) force is applied to one panel at any point up to 42 inches (1067 mm) above finished floor less than thickness of glass.
4. Thermal and Solar Optical Performance: Measured or calculated in accordance with the following:
   a. U-Values: NFRC 100.
   b. Solar Heat Gain Coefficients: NFRC 200.
   c. Solar Optical Properties: NFRC 300.

2.02 FLOAT GLASS PRODUCTS

A. Low E Glass:

1. Heat strengthened tinted or tempered tinted float glass as specified; Class 2 tinted.
2. Minimum Thickness: 1/4 inch.
3. Tint: Gray.
4. Coating: ASTM C1376; pyrolytic.

B. Manufacturers:

1. ACH Glass Operations
2. AFG Industries, Inc.
3. Oldcastle Glass.

2.03 INSULATING GLASS PRODUCTS

A. Insulating Glass:

1. ASTM E2190 certified by Insulating Glass Certification Council and Insulating Glass Manufacturers Alliance; with glass elastomer edge seal; purge interpane space with dry hermetic air.

2. Total Unit Thickness: 1 inch unless otherwise indicated.
3. Insulating Glass Unit Edge Seal Construction: Aluminum, thermally broken, bent and soldered corners.

2.04 GLAZING SEALANTS

A. Elastomeric Glazing Sealants: Materials compatible with adjacent materials including glass**,** insulating glass seals, and glazing channels.

1. Silicone Glazing Sealant: ASTM C920, Type S, Grade NS, Class and Use suitable for glazing application indicated; single component curing; capable of water immersion without loss of properties; nonbleeding, nonstaining, cured Shore A Hardness Range 15 to 25.

B. Dense Gaskets:

1. Resilient extruded shape to suit glazing channel retaining slot; black.
2. Neoprene: ASTM C864.
3. EPDM: ASTM C864.
4. Silicone: ASTM C1115.

C. Soft Gaskets:

1. ASTM C509 Type II; resilient extruded shape to suit glazing channel retaining slot; black.
2. Neoprene.
3. EPDM.
4. Silicone.

D. Preformed Glazing Tape:

1. Size to suit application.
2. Preformed butyl compound with integral resilient tube spacing device; 10 to 15 Shore A durometer hardness; coiled on release paper; black color.
3. Butyl Corner Sealant: ASTM C920 single component nonskinning butyl compatible with glazing tape; color to match tape.

2.05 GLAZING ACCESSORIES

A. Setting Blocks: Elastomeric material recommended by glass manufacturer, 80 to 90 Shore A durometer hardness, length of 0.1 inch for each square foot (25 mm for each square meter) of glazing or minimum 4 inch (100 mm) by width of glazing rabbet space minus 1/16 inch (1.5 mm) by height to suit glazing method and pane weight and area.

B. Spacer Shims: Elastomeric material recommended by glass manufacturer, 50 to 60 Shore A durometer hardness, minimum 3-inch (75-mm) long by one half the height of glazing stop by thickness to suit application**,** self-adhesive on one face.

C. Glazing Clips: Manufacturer's standard type.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify openings for glazing are correctly sized and within acceptable tolerance.

B. Verify surfaces of glazing channels or recesses are clean, free of obstructions impeding moisture movement, weeps are clear and ready to receive glazing.

3.02 PREPARATION

A. Do not perform glazing work in damp, foggy, or rainy weather, or when temperatures are not within range recommended by GANA “Glazing Manual”.

B. Surfaces:

1. Smooth, even, sound, dry, and clean.
2. Clean contact surfaces with solvent and wipe dry.

C. Priming:

1. Complete and cured.
2. Prime surfaces scheduled to receive sealant.

D. Measure size of frames to receive glass and compute actual glass size allowing for edge clearances.

E. Verify functioning weep system is present.

F. Do not proceed with glazing until unsatisfactory conditions have been corrected.

3.03 GLAZING INSTALLATION

A. General: Follow recommendations of glass manufacturer GANA “Sealant Manual, GANA “Glazing Manual” and the following:

1. Glazing Sealants: Comply with ASTM C1193.
2. Fire Rated Openings: Comply with NFPA 80.

B. Exterior Wet/Dry Method (Preformed Tape and Sealant) Installation:

1. Cut glazing tape to length and set against permanent stops, 3/16 inch (5 mm) below sight line. Seal corners by butting tape and dabbing with compatible butyl sealant.
2. Apply heel bead of butyl sealant along intersection of permanent stop with frame ensuring full perimeter seal between glass and frame to complete continuity of air and vapor seal.
3. Place setting blocks at 1/4 points with edge block no more than 6 inches (150 mm) from corners.
4. Rest glazing on setting blocks and push against tape and heel bead of sealant with sufficient pressure to attain full contact at perimeter of pane or glass unit.
5. Fill gap between glazing and stop with elastomeric glazing sealant to depth equal to bite of frame on glazing, but not more than 3/8 inch (9 mm) below sight line.
6. Apply cap bead of elastomeric glazing sealant along void between stop and glazing, to uniform line, flush with sight line. Tool or wipe sealant surface smooth.

C. Interior Dry Method (Tape and Tape) Installation:

1. Cut glazing tape to length and set against permanent stops, projecting 1/16 inch (1.6 mm) above sight line.
2. Place setting blocks at 1/4 points with edge block no more than 6 inches (150 mm) from corners.
3. Rest glazing on setting blocks and push against tape for full contact at perimeter of pane or unit.
4. Place glazing tape on free perimeter of glazing in same manner described above.
5. Install removable stop without displacement of tape. Exert pressure on tape for full continuous contact.
6. Knife trim protruding tape.

3.04 FIELD QUALITY CONTROL

A. Hose Test:

1. Use 3/4-inch minimum hose without nozzle. With full stream, flood glazing from bottom to top.
2. Correct leaks disclosed by hose test by reglazing and retesting until eliminated.

3.05 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance and inspection.

3.06 CLEANING

A. Leave glass and glazing in undamaged condition and ready for final cleaning.

B. Remove excess glazing compound from installed glass.

C. Remove labels from glass surface at time of final cleaning.

D. Wash and polish both faces of glass.

E. Clean adjacent surfaces of glass.

3.07 PROTECTION OF COMPLETED WORK

A. Protection:

1. Keep glass free from contamination by materials capable of staining glass.
2. Install tape across lights secured to frames or structure.
3. No tape or marking allowed on glass.

B. Replacements and Repairs: Prior to Substantial Completion, replace broken, defective, or scratched glass and repair damaged compounds.

END OF SECTION

SECTION 08 90 00
LOUVERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500-L, Laboratory Methods of Testing Louvers for Rating.
2. ASTM International (ASTM):
   a. D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.

1.02 DESIGN REQUIREMENTS

A. Wind Loads: Provide louver assemblies and their anchorage to the wall structure that are capable of withstanding the positive and negative wind load pressures shown on the Components and Cladding Wind Surface Pressures table on the Structural Drawings.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Large scale details of louvers, anchorage, and relationship to adjoining construction.
   a. Manufacturer's Literature: Descriptive and performance data of louvers, including standard drawings and louver-free area.
2. Samples: Manufacturer's standard finishes and colors.

B. Informational Submittals:

1. Factory test data.
2. Certificates of AMCA ratings.
3. Installation instructions.
4. Parts list, if applicable.
5. Maintenance procedures.
6. Special Guarantee.
7. Third party testing documentation or manufacturer's literature qualifying louver assembly as meeting required developed wind pressures for Project as shown on the Components and Cladding Wind Surface Pressures table on the Structural Drawings.

1.04 SPECIAL GUARANTEE

A. Manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction, or at option of Owner, removal and replacement of special fluorocarbon or baked-on finish found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

A. Nonacoustical louver sizes are based on 50 percent free area and 800 fpm maximum velocity through free area. If louvers furnished do not meet these parameters, Contractor is responsible for resizing louvers and wall openings, and for making other adjustments to allow for larger openings.

B. Water Penetration Rate: No greater than 0.02 ounce per square foot.

C. Louvers: Rated and tested in accordance with AMCA 500-L.

D. Furnish louvers with interior duct collars.

2.02 FIXED STORMPROOF LOUVERS (TYPE SP)

A. Frame: Extruded aluminum channel, 0.081 inch thick, 4 inches deep, with concealed mullions.

B. Blades: Extruded aluminum, 0.081 inch thick, Z-shaped, 35-degree to 45-degree pitch angle, spaced 3 inches to 4.25 inches on center.

C. Pressure Loss: AMCA certified rating of no greater than 0.10-inch WC.

D. Sizes: As shown on Drawings.

E. Insect Screen: Inside mounted, painted aluminum.

F. Finish: Kynar 500 fluorocarbon coating.

G. Manufacturers and Products:

1. Construction Specialties; Model 4110.
2. Dowco; Series LEB-4.
3. Ruskin; Model ELF-375DXH.

2.03 ACCESSORIES

A. Anchors and Fasteners: Stainless steel.

B. Flashings: Match louver frame.

C. Isolation Tape: Tremco 440, 3M EC1202, or Presstite 579.6.

D. Isolation Paint: ASTM D1187, bituminous coating.

2.04 SOURCE QUALITY CONTROL

A. Factory Performance Tests:

1. Airflow versus pressure loss.
2. Rain penetration data.

PART 3 EXECUTION

3.01 EXAMINATION

A. Check openings to ensure dimensions conform to Drawings.

B. Ensure openings are free of irregularities that would interfere with installation.

C. Do not install louvers until defects have been corrected.

3.02 INSTALLATION

A. Install louvers as shown on reviewed Shop Drawings. Coordinate with heating or ventilation ductwork to be connected.

B. Follow procedures in manufacturer’s recommended installation instructions.

C. Separate aluminum from other metals with isolation tape or paint.

3.03 CLEANING

A. After erection, protect exposed portions from damage by machines, paint, lime, acid, cement, or other harmful compounds.

B. Remove protective materials and clean with plain water, water with soap, or household detergents.

END OF SECTION

SECTION 09 29 00
GYPSUM BOARD

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): A118.9, Test Methods and Specifications for Cementitious Backer Units.
2. ASTM International (ASTM):
   a. A641/A641M, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
   b. C208, Standard Specification for Cellulosic Fiber Insulating Board.
   c. C475/C475M, Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board.
   d. C514, Standard Specification for Nails for the Application of Gypsum Board.
   e. C645, Standard Specification for Nonstructural Steel Framing Members.
   f. C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
   g. C754, Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products.
   h. C840, Standard Specification for Application and Finishing of Gypsum Board.
   i. C1002, Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs.
   j. C1047, Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base.
   k. C1177/C1177M, Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing.
   l. C1178/C1178M, Standard Specification for Glass Mat Water-Resistant Gypsum Backing Panel.
   m. C1396/C1396M, Standard Specification for Gypsum Board.
   n. D4977, Standard Test Method for Granule Adhesion to Mineral Surfaced Roofing by Abrasion.
   o. D5420, Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact).
   p. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

q. E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
r. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.
s. E413, Classification for Rating Sound Insulation.
t. E695, Standard Test Method of Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading.

3. Gypsum Association (GA):
   a. 214, Recommended Levels of Gypsum Board Finish.
   b. 216, Application and Finishing of Gypsum Panel Products.
4. Underwriters Laboratories Inc. (UL): UL Fire Resistance Directory.

1.02 SUBMITTALS

A. Submittals:

1. Control joint pattern proposed for gypsum board.
2. Control joint pattern proposed for gypsum soffit.
3. Manufacturer's list of items and materials proposed for use, with descriptive literature for each system used.

1.03 QUALITY ASSURANCE

A. General: Regardless of the minimum specifications herein, utilize materials and applications recommended by manufacturer.

B. Applicator's Qualifications: Use only workers regularly employed in this type of work who can show experience in application of similar materials and specific systems specified.

C. Single Source Responsibility: Use gypsum board and related joint treatment materials from a single manufacturer for each type used.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver fire-rated materials bearing testing agency label and required fire classification numbers.

B. Storage:

1. Store materials inside, under cover, stacked flat, off floor.
2. Stack gypsum board so that long lengths are not over short lengths.
3. Avoid overloading floor system of storage area.
4. Store adhesives and finishing compounds in dry areas; protect against freezing at all times.

1.05 ENVIRONMENTAL CONDITIONS

A. Temperature: In areas receiving gypsum board installation, maintain minimum temperature of 40 degrees F for 48 hours before, during, and after gypsum board application. Maintain minimum temperature of 50 degrees F for 48 hours before, during, and after application of adhesive methods of attachment and finishing compounds until drying is complete.

B. Ventilation:

1. Provide ventilation during and following adhesives and joint treatment applications.
2. Use temporary air circulators in enclosed areas lacking natural ventilation.
3. Under slow drying conditions, allow additional drying time between coats of joint treatment.
4. Protect installed materials from drafts of ambient air during hot, dry weather.
5. Protect materials from drying too rapidly during hot and dry weather.

PART 2 PRODUCTS

2.01 GYPSUM BOARD

A. Regular Board (GWB): ASTM C1396/C1396M, 5/8-inch thick with tapered edges.

B. Fire-Rated Board (GWBX): ASTM C1396/C1396M, Type X, 5/8-inch thick with tapered edges.

2.02 TILE BACKING PANELS

A. Cementitious Backer Board (CBB):

1. Aggregated portland cement panel reinforced with vinyl-coated, woven fiberglass mesh embedded in both surfaces meeting ANSI A118.9.
2. Thickness: 1/2-inch.
3. Manufacturers and Products:
   a. Custom Building Products; Wonderboard.
   b. United States Gypsum; Durock.

2.03 FASTENERS

A. Gypsum Board:

1. Annular Ring Nail: ASTM C514, GWB-54, 1-1/4 inches long for 1/2-inch gypsum board, and 1-3/8 inches long for 5/8-inch gypsum board.

2. Smooth Shank Nail: ASTM C514, 1-3/8 inches long for 1/2-inch gypsum board, and 1-1/2 inches long for 5/8-inch gypsum board.
3. Screws: ASTM C1002, self-drilling, self-tapping, bugle head, for use with power-driven tool.
   a. Type S, 1 inch long for gypsum board to sheet metal.
   b. Type W, 1-1/4 inches long for gypsum board to wood.

2.04 JOINT TREATMENT MATERIALS

A. Tape:

1. General Interior Applications: ASTM C475/C475M, perforated paper tape.
2. Soffit Board, Glass Mesh Mortar Units, and Cementitious Backer Board: 2-inch wide 10 by 10 open weave glass mesh tape as recommended by manufacturer.

B. Compound:

1. General Interior Applications: ASTM C475/C475M, all-purpose, ready-mixed compound.
2. Water-Resistant GWB and Soffit Boards: Chemically curing, polyindurate type material as recommended by manufacturer.

2.05 ANCILLARY MATERIALS

A. Sound Attenuation Blankets: ASTM C665, Type I (no facing), **3** inches thick.

B. Acoustical Sealant:

1. Nonsetting and nonstaining with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers:
   a. DAP.United States Gypsum.
   b. Tremco.
   c. Ohio Sealants, Inc.

2.06 TRIM ACCESSORIES

A. ASTM C1047, Zinc-Coated Metal.

B. Manufacturers and Products:

1. Corner Bead:
   a. 1-1/4 inches by 1-1/4 inches:
      1) United States Gypsum; Dur-A-Bead.
      2) Gold Bond; standard corner beads.

2. Edge Trim:
   a. United States Gypsum; 200B metal trim.
   b. Gold Bond; No. 200 casing bead.
3. Metal Control Joint:
   a. United States Gypsum; No. 093.
   b. Gold Bond; E-Z strip control joint.

2.07 NONSTRUCTURAL METAL FRAMING MEMBERS

A. ASTM C645, galvanized C-studs with 1-5/8-inch flanges and C-H studs with J-runners**.**

B. Sizes and Gauge: As noted on Drawings.

C. Manufacturers:

1. United States Gypsum.
2. Dale/Incor.
3. Gold Bond.
4. Unimast, Inc.

2.08 LIGHT-GAUGE METAL FRAMING ACCESSORIES

A. Cold-Rolled Carrying Channel: Cold-rolled steel, 16-gauge metal with minimum 1/2-inch wide flange, galvanized 1-1/2 inches deep.

B. Cold-Rolled Bridging Channel: Cold-rolled steel, 16-gauge metal with minimum 1/2 inch wide flange galvanized 1-1/2 inches deep.

C. Cold-Rolled Furring Channel: Cold-rolled steel, 25-gauge metal with minimum 1/2-inch wide flange, galvanized 3/4 inches deep.

D. Z-Furring: Galvanized 25-gauge, 2-1/2 inch(es) deep.

E. Hat-Shaped Furring Channels: Roll-formed hat shaped section of 25-gauge galvanized steel with a face width of 1-1/4 inches and a depth of 7/8 inch(es).

F. Resilient Furring Channels: Roll-formed section of 25-gauge galvanized steel with face width of 1-1/2 inches designed for resilient attachment of gypsum board to framing.

G. Hanger Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.162-inch diameter.

H. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.625-inch diameter or double strand of 0.0475-inch diameter wire.

2.09 DRY WALL CEILING SUSPENSION SYSTEM

A. Use system of main runners, cross tees, and furring channels.

B. Manufacturers:

1. Armstrong World Industries, Inc.; Furring Systems/Drywall.
2. USG Interiors, Inc.; Drywall Suspension System.

2.10 SPRAY TEXTURE

A. Manufacturers and Products:

1. Aggregate Finish:
   a. National Gypsum Company; ProForm Spray Quick.
   b. United States Gypsum Company; Ceiling Spray Texture.

B. Manufacturers and Products:

1. Nonaggregate Finish:
   a. National Gypsum Company; ProForm Perfect Spray EM/HF.
   b. United States Gypsum Co.; SHEETROCK Wall and Ceiling Spray Texture (unaggregated).

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect surfaces to receive gypsum board and related materials before beginning work and report to Engineer any defects in such work which will adversely affect the quality of work specified herein.

3.02 PREPARATION

A. General: Provide, install, and maintain necessary scaffold, staging, trestles, planking, and temporary heating, lighting, and ventilation as necessary for duration of gypsum board work.

B. Protection: Protect work of other trades.

C. Coordination:

1. Coordinate work with that of other trades. Check specifications and drawings of other trades to determine parts of work requiring coordination.
2. Cut and repair gypsum board systems for installation of omitted work.

D. Surface Preparation: Repair defective surfaces prior to starting work. Prepare as specified for application of specific materials.

3.03 ERECTION OF SUSPENDED CEILING

A. General:

1. Securely brace all ceiling areas against sway as required by code for seismic control.
2. Prevent runner and furring channels from contacting masonry walls.
3. Provide 1-1/2-inch channels around recessed lighting fixture openings to support fixtures.

B. Hangers:

1. Space not over 4 feet on center (OC) in direction of runners and within 6 inches of ends of runners.
2. Securely attach to structure above and provide for full saddle tie to main runner at indicated height.
3. Install additional hangers at ends of each suspension member and at light fixtures, 6 inches from vertical surfaces.
4. Do not splay wires more than 5 inches in a 4-foot vertical drop.
5. Provide four-way wire splays at 45 degrees from main runner to support structure for every 144 square feet of ceiling area to prevent sway.
6. Wrap wire minimum three times horizontally, turning ends upward.
7. Where hanger wires cannot be hung vertically from structure above because of ducts, pipes, cable trays, or other interferences, provide trapezes of steel channels (minimum 2-inch deep, 16-gauge cold-rolled carrying channels) hung on steel rods or 8-gauge wire from structural members above. Hang ceiling wires from trapezes or similar members supporting ducts or pipes. Do not hang directly from ducts or pipes.

C. Main Runner Channels:

1. Run main runner channels spaced not more than 4 feet OC, and 6 inches from parallel walls, at right angles to the length of joists.
2. Overlap splices in main runners 12 inches minimum, interlock flanges, and securely tie near each end of splice with double loops of tie wire.

D. Furring Channels:

1. Attach furring channels to main runners at right angles, space at 16 inches OC.
2. Securely saddle tie furring to the main runners at each crossing or equivalent clips or attachments.
3. Splices in Cross-Furring: Lap 8 inches minimum, interlock flanges, and securely tie near each end of splice with two loops of tie wire.

3.04 ERECTION OF DRY WALL CEILING SUSPENSION SYSTEM

A. Follow manufacturer's printed instructions.

B. Hangers:

1. Space not over 4 feet OC in direction of runners and within 6 inches of ends of runners.
2. Securely attach to structure above and provide for full saddle tie to main runner at indicated height.
3. Connections shall develop full strength of hanger wire.

C. Bracing:

1. Securely brace ceiling areas against sway.
2. Where required by code, install for seismic control.
3. Prevent runner and furring channels from contacting masonry walls.

D. Where ducts interfere with normal spacing of hangers and carrying channels, install additional hangers and channels to properly suspend ceiling.

3.05 ERECTION OF LIGHT-GAUGE NONSTRUCTURAL METAL FRAMING

A. Layout: Align partitions as shown on Drawings.

B. Tracks:

1. Attach metal runner tracks to floor slabs with suitable fasteners located 2 inches from each end and spaced not more than 24 inches OC.
2. Where partitions terminate at suspended or framed ceilings attach top tracks to suspended ceiling with toggle or molly bolts spaced 24 inches OC.
3. Where partitions terminate above suspended ceilings provide diagonal bracing from top of partitions to structure above. Bracing shall be 3-5/8-inch metal studs staggered at 48 inches OC.
4. Where partitions terminate at underside of concrete or metal decking attach deflection channels to substrate with suitable fasteners located 2 inches from each end and spaced not more than 24 inches OC. Locate partition top tracks within deflection channels with a minimum top clearance of 1 inch. Do not attach track to channel.

C. Studs:

1. ASTM C754.
2. Following manufacturer's printed instructions, position studs vertically, engaging floor and ceiling tracks and spaced as noted on Drawings.

3. Splice: When necessary, use 8-inch nested lap and one positive attachment per stud flange.
4. Place in direct contact with doorframe jambs, abutting partitions, and partition corners. Provide for anchorage of doorframes to studs.
5. Anchor studs for shelf-walls and those adjacent to window and doorframes, partition intersections, and corners to ceiling and floor runner flanges. Securely anchor studs to jamb and head anchor clips of door or borrowed-light frames by bolt or screw attachment.
6. Over metal door and borrowed-light frames, place horizontally a cut-to-length section of runner, with a web-flanged bend at each end, and secure with one positive attachment per flange. Position a cut-to-length stud (extending to ceiling runner) at vertical panel joints over doorframe header.
7. Locate studs at abutting construction, partition intersections, and partition corners.
8. Spacing: At 16 inches OC, unless otherwise required by manufacturer.
9. At Doorframes and Cased Openings:
    a. Full height double studs, No. 20 gauge minimum, secured to jamb anchors by bolts, screws, or welds.
    b. Header Track: Secure to frame head anchors and double studs.
    c. Provide double channel stiffeners through studs above frame and extend at least one stud space beyond each jamb.
10. Windows: Similar framing to door openings with stiffeners both above and below.
11. Wall Mounting Accessories: Provide channels, horizontal studding, No. 16 gauge sheet 8 inches by 2 inches greater than stud spacing, or other members within walls as required to provide secure and adequate support.

D. Furring:

1. Space furring channels the same as studs or as shown.
2. Around columns and beams construct furring as shown using metal studs and furring channels securely tied together and anchored in-place.
3. Attach resilient furring channels to wood framing with screws.

3.06 APPLICATION OF GYPSUM BOARD

A. Inspection and Preparation:

1. Check framing for accurate spacing and alignment.
2. Verify spacing of installed framing does not exceed maximum allowable for thickness of gypsum board to be used.
3. Verify frames are set for thickness of gypsum board to be used.

4. Do not proceed with installation of gypsum board until deficiencies are corrected and surfaces to receive gypsum board are acceptable.
5. Repair protrusions of framing, twisted framing members, or unaligned members before installation of gypsum board is started.

B. General:

1. Meet requirements of ASTM C840 and GA 216.
2. Joints: Use gypsum board of maximum lengths to minimize end joints. Stagger end joints when they occur. Locate end joints as far as possible from center of wall or ceiling. Abut gypsum board without forcing. Neatly fit ends and edges of gypsum board. Do not place butt ends against tapered edges.
3. Support ends and edges of gypsum board panels on framing or furring members except for face layer of double layer and where ends are back blocked and floated.
4. Use metal edge trim where gypsum board abuts another material, at corners, and where shown or noted on Drawings.
5. Use cementitious backer board in toilet, shower, and janitor room walls behind ceramic tile and elsewhere as indicated on Drawings
6. Follow manufacturer’s recommendation of good practice.

C. Over Framing:

1. Apply gypsum board first to ceiling and then to walls for single layer horizontal application.
2. Use vertical application for fire-rated walls.
3. Fasten gypsum board securely to framing using screw method.

D. Sound-Rated Partitions:

1. Fabricate and erect in accordance with manufacturer’s printed instructions for required rating.
2. Install sound-deadening board and attenuation blankets as detailed.
3. Seal with acoustical sealant perimeter edges of gypsum board, joints around penetrations, and other joints as noted.

3.07 INSTALLATION OF CEMENTITIOUS BACKER BOARD (CBB)

A. Follow manufacturer’s printed instructions for erection, cutting, attachments, and joint treatment.

B. Verify framing is installed at maximum 16 inches OC, and necessary blocking to support fixtures and accessories has been installed. Where backing plates or straps are used, space out from framing to ensure a smooth finish application. Do not proceed until defects are corrected and are acceptable.

C. Precut boards to required sizes and make necessary cutouts. Fasten with appropriate fasteners. Space fasteners 6 inches OC maximum or as directed by manufacturer. Fit ends closely but not forced together. Maintain 1/4-inch spacing between edge of board and fixture. Caulk all joints and corners that are to receive tiles. Apply 2-inch glass fiber tape over joints and corners embedded with tile setting mortar.

3.08 JOINT SYSTEM FOR GYPSUM WALLBOARD

A. Interior Gypsum Board: Conform to ASTM C840.

B. Required: On exposed gypsum board, under ceramic tile and wall covering, and behind casework.

C. Prefill: Fill V-grooves formed by abutting rounded edges of gypsum board with prefill joint compound. Fill V-joint flush and remove excess compound beyond groove. Leave clear depression to receive tape. Permit prefill joint compound to harden prior to application of tape.

D. Taping and Finishing Joints:

1. Taping or Embedding Coat: Apply compound in thin, uniform layer to joints and angles to be reinforced. Apply reinforcing tape immediately. Center tape over joint and seat tape into compound. Leave approximately 1/64-inch to 1/32-inch compound under tape to provide bond. Apply skim coat immediately following tape embedment but not to function as fill or second coat. Fold tape and embed in angles to provide true angle. Dry embedding coat prior to application of fill coat.
2. Filling Coat: Apply joint compound over embedding coat. Fill taper flush with surface. Apply fill coat to cover tape. Feather out fill coat beyond tape and previous joint compound line. For joints with no taper, feather out at least 4 inches on either side of tape. Do not apply fill coat on interior angles. Allow fill coat to dry prior to application of finish coat.
3. Finishing Coat: Spread joint compound evenly over and beyond fill coat on joints. Feather to smooth uniform finish. Apply finish coat to taped angles to cover tape and taping compound. Sand final application of compound to provide surface ready for decoration.
4. Filling and Finishing Depressions: Apply joint compound as first coat to fastener depressions. Apply at least two additional coats of compound after first coat is dry. Leave filled and finished depressions level with plane of surface.

E. Finishing Beads and Trim:

1. First Fill Coat: Apply joint compound to bead and trim. Feather out from ground to plane of the surface. Dry compound prior to application of second fill coat.
2. Second Fill Coat: Apply joint compound in same manner as first fill coat. Extend beyond first coat onto face of gypsum board. Dry compound prior to application of finish coat.
3. Finish Coat: Apply joint compound to bead and trim. Extend beyond second fill coat. Feather finish coat from ground to plane of surface. Sand finish coat to provide flat surface ready for decoration.

3.09 FINAL FINISHES FOR GYPSUM WALLBOARD

A. Levels of Finish: Conform to GA 214.

B. Level 1:

1. Taping or embedding coat only.
2. Use in concealed areas, and where indicated, unless a higher level is required for fire-resistive or sound-rated assemblies.

C. Level 2:

1. Taping, filling, and finishing coats.
2. Use on water-resistant gypsum backing board.

D. Level 3:

1. Taping, filling, and finishing coats.
2. Use on surfaces indicated to have spray texture or ceramic tile.

E. Level 4:

1. Taping, filling, and finishing coats plus two separate coats applied over joints, angles, fastener heads, and trim accessories.
2. Sand between coats and after last coat.
3. Use on surfaces indicated to receive wall coverings.

F. Level 5:

1. Same as Level 4, plus a thin, smooth, uniform skim coat of joint compound, or product specially formulated for this purpose, over entire surface.
2. Produce surfaces free of tool marks and ridges, ready for decoration.
3. Use on surfaces not indicated otherwise, those indicated to receive gloss, semi-gloss, and nontextured flat paints, and where indicated.

3.10 SPRAY TEXTURE

A. Application:

1. Apply on gypsum board ceilings surfaces following manufacturer's printed directions for a medium build orange peel texture.
2. Before texture application, finish gypsum board as specified for Level 3.
3. When surfaces are prepared and dry, apply sealer and allow to dry. Mix texture finish material as directed by manufacturer.
4. Use spray equipment of a size and type to assure acceptable results.
5. Apply by spray only at a coverage rate as recommended by manufacturer and in accordance with directions printed on container. Apply material to blend uniformly and cover fully without starved spots or other evidence of thin application. Provide uniform texture without application patterns.
6. After spray application, knockdown and flatten high spots with trowel to produce a Brocade or Travertine marble texture.

3.11 ADJUST AND CLEAN

A. Clean: Remove droppings or texture overspray from walls, windows, and floor, leaving room clean for following trades.

B. Nail Pop: Repair nail pop by driving new nail approximately 1-1/2 inches from nail pop and reseat nail. When face paper is punctured, drive new nail or screw approximately 1-1/2 inches from defective fastening and remove defective fastening. Fill damaged surface with compound.

C. Ridging:

1. Do not repair ridging until condition has fully developed, approximately 6 months after installation or one heating season.
   a. Sand ridges to reinforcing tape without cutting through tape.
   b. Fill concave areas on both sides of ridge with topping compound.
   c. After fill is dry, blend in topping compound over repaired area.
2. Fill cracks with compound and finish smooth and flush.

END OF SECTION

SECTION 09 30 00
TILING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A108.1A, Installation of Ceramic Tile in the Wet-Set Method with Portland Cement Mortar.
   b. A108.1B, Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex-Portland Cement Mortar.
   c. A108.1C, Contractor's Option: Installation of Ceramic Tile in the Wet-Set Method with Portland Cement Mortar or Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex-Portland Cement Mortar.
   d. A108.4, Installation of Ceramic Tile with Organic Adhesives or Water Cleanable Tile-Setting Epoxy Adhesive.
   e. A108.5, Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar.
   f. A108.6, Installation of Ceramic Tile with Chemical Resistant, Water Cleanable Tile-Setting and Grouting Epoxy.
   g. A108.8, Installation of Ceramic Tile with Chemical Resistant Furan Resin Mortar and Grout.
   h. A108.9, Installation of Ceramic Tile with Modified Epoxy Emulsion Mortar/Grout.
   i. A108.10, Installation of Grout in Tilework.
   j. A108.11, Interior Installation of Cementitious Backer Units.
   k. A118.1, Dry-Set Portland Cement Mortar.
   l. A118.3, Chemical Resistant, Water Cleanable Tile-Setting and Grouting Epoxy and Water-Cleanable Tile-Setting and Grouting Epoxy and Water Cleanable Tile-Setting Epoxy Adhesive.
   m. A118.4, Latex-Portland Cement Mortar.
   n. A118.5, Chemical Resistant Furan Mortars and Grouts for Tile Installation.
   o. A118.6, Standard Cement Grouts for Tile Installation.
   p. A118.10, Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone Installation.
   q. A136.1, Organic Adhesives for Installation of Ceramic Tile.
   r. A137.1, Ceramic Tile.

2. ASTM International (ASTM):
    a. A497/497M, Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete.
    b. C144, Standard Specification for Aggregate for Masonry Mortar.
    c. C150, Standard Specification for Portland Cement.
    d. C206, Standard Specification for Finishing Hydrated Lime.
    e. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
    f. C267, Standard Test Method for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
    g. C395, Standard Specification for Chemical-Resistant Resin Mortars.
    h. C847, Standard Specification for Metal Lath.
    i. C920, Standard Specification for Elastomeric Joint Sealants.
    j. D226, Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
3. South Coast Air Quality Management District: SCAQMD Rule 1168 – Adhesive and Sealant Applications.
4. Tile Council of North America (TCA): Handbook for Ceramic Tile Installation.

1.02 SUBMITTALS

A. Action Submittals:

1. Samples:
    a. Two for each color, pattern, and type of tile specified.
    b. Size: Approximately 12 inches square.
    c. Mark Samples clearly to indicate color or shade, location in which to be used, and manufacturer’s name.

B. Informational Submittals:

1. Certification of Compliance: For tile, mortar, grouts, and adhesives.
2. Manufacturer’s Instructions: For storage, mixing, application, cleanup, and use of proposed mortars, grouts, and adhesives.
3. Tile Manufacturer’s Maintenance Guidelines: For Owner’s use in maintaining ceramic tilework specified herein.

1.03 QUALITY ASSURANCE

A. Perform Work in accordance with TCA Handbook and ANSI A108 Series/A118 Series.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Set and grout tile in portland cement mortar when ambient temperature is at least 50 degrees F and rising. Follow ANSI A108.1A or ANSI A108.1B, as recommended by ANSI A108.1C.

B. Comply with minimum temperature recommendations of manufacturers for bonding and grouting materials other than portland cement mortar.

1.05 EXTRA MATERIALS

A. Tile: Furnish extra 2 percent of each tile used in clean, marked cartons for Owner's future use.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and products specified in this section shall be products of:

1. American Olean Tile Co.
2. Dal-Tile Corp.
3. United States Ceramic Tile Co.

2.02 MATERIALS

A. Unglazed Ceramic Floor Tile: ANSI A137.1, Section 5.1, porcelain type, smooth cushion edge, nominal face size 12 inches by 24 inches. Furnish slip-resistant tile with 7-1/2 percent abrasive grain content in all areas where floor tile is scheduled or shown on the drawings.

B. Glazed Wall Tile:

1. ANSI A137.1, Section 6.1.
2. Cushion edges, face finished with colored bright glaze, nominal face size 3 inches by 6 inches.

C. Trim Shapes and Bases: Type, color, and finish to match wall tiles.

D. Latex-Portland Cement Mortar: ANSI A118.4.

E. Latex-Portland Cement Grout: Portland cement grout with latex additive, commercial quality, ANSI A118.6.

2.03 ANCILLARY MATERIALS

A. Expansion Joints:

1. Sealant: Silicone rubber type, meeting ASTM C920, Type S, Grade P, Class 25, Use T, color to match grout, with Shore A hardness of minimum 25 for joints in horizontal surfaces and minimum 35 in traffic areas.
2. Backup Material: Flexible and compressible type, nonstaining and compatible with sealants used.

B. Edge Strips: Stainless steel, Alloy 316 flat bar, 1/8 inch by depth of tile and mortar.

C. Shower Pan: Membrane that meets the requirements of local authority having jurisdiction or governing building code.

D. Shower Wall Membrane: ANSI A118.10; composite, sheet membrane made from PVC with non-woven fiber laminated to both sides. Manufacturer and Product: Noble Co.; Wall Seal.

E. Tile Cleaner: Neutral tile cleaner solution acceptable to tile manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine surfaces to receive ceramic tile, setting beds, or accessories prior to tile installation.

B. Correct defects or adverse conditions affecting quality and execution of tile installation.

C. Surfaces to receive tile shall be plumb, level, and true with square corners.

D. Tolerances for Surfaces to Receive Tile:

1. Portland Cement and Epoxy Mortar Methods:
   a. Maximum Variation in Subfloor Surface: 1/4 inch in 10 feet.
   b. Maximum Variation in Vertical and Ceiling Surfaces: 1/4 inch in 8 feet.

E. Grounds, anchors, plugs, hangers, bucks, electrical and mechanical work, in or behind tile, to be installed prior to proceeding with tilework.

F. Protection: Protect adjoining work surfaces before tilework begins.

G. Make substrate firm, dry, clean, and free of oily or waxy films.

3.02 INSTALLATION

A. Prepare surfaces, fit, set, or bond tile, grout and clean tile in accordance with applicable requirements of ANSI Standards for setting method specified, except as otherwise noted.

B. Workmanship, Cutting, Fitting, and Grout Joint Size:

1. Center and balance areas of tile.
2. Generally start full size tiles at outside corners and leave cut tiles for inside corners.
3. Tile Cutting:
    a. Minimize number of cuts.
    b. No cuts smaller than half size without approval of Engineer.
    c. Make all cuts on the outer edges of the field.
    d. Smooth cut edges. Install tile without jagged or flaked edges.
    e. Do not split tile unless no other alternative is possible.
4. Fit tile closely where edges will be covered by trim, escutcheons, or other similar devices.
5. Maintain heights of tile work in full courses to nearest obtainable dimension where heights are given in feet and inches and are not required to fill vertical spaces exactly.
6. Allowable Lippage: 1/32 inch.
7. Grout Joint Size: 1/8 inch.
8. Install accessories in tile work to be evenly spaced, properly centered with tile joints, and level, plumb, and true to the correct projection. Install accessories at locations and heights shown or designated.

C. Trim: Provide bases, caps, stops, returns, trimmers, and other shapes to finish installation.

D. Setting Wall Tile (Thin-Set Application):

1. On Cementitious Backer Board Walls: Meet TCA Method W244C.
2. Use latex-portland cement grout.

E. Setting Floor Tile (Thin-Set Application):

1. On Concrete: Meet TCA Method F113 with latex-portland cement grout**.**

F. Edge Strips:

1. At openings without thresholds and similar discontinuous edges of thin-set tile floors.

2. Where ceramic tile floors are adjacent to other flooring material at same level.
3. Where ceramic tile cove base is combined with other types of flooring.

3.03 CLEANING AND SEALING

A. Clean tile surfaces thoroughly on completion of grouting.

B. Remove grout haze, observing tile manufacturer's recommendations as to use of acid and chemical cleaners.

C. Rinse tilework thoroughly with clean water before and after using chemical cleaners.

D. Polish surface of glazed tilework with soft cloth.

E. After grout has cured for 10 days, clean and seal nonglazed tiles following sealer manufacturer's instructions and recommendations.

3.04 PROTECTION

A. From Construction Dirt:

1. Apply protective coat of neutral cleaner solution, one part cleaner to one part water, to clean completed tile walls and floors.
2. Cover tile floors with heavy-duty, nonstaining construction paper, masked in-place.
3. Just before substantial completion, remove paper and rinse protective coat of neutral cleaner from tile surfaces.

B. From Traffic:

1. Prohibit foot and wheel traffic from using newly tiled floors for at least 7 days.
2. Place large, flat boards in walkways and wheelways for 7 days where use of newly tiled floor with cement type grout is unavoidable.

END OF SECTION

SECTION 09 51 23
ACOUSTICAL TILE CEILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. A641/A641M, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
   b. C635/C635M, Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings.
   c. C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels.
   d. E1264, Standard Classification for Acoustical Ceiling Products.
2. Underwriters Laboratories Inc. (UL): Fire Resistance.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed layout of grid indicating hanger spacing, fastening and splicing details, change in level details, and access location.
   b. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads shown on General Structural Notes on Drawings.
2. Samples:
   a. One 12-inch square of each acoustical unit material to illustrate range of appearance.
   b. One full-size Sample of each suspension system member and molding.
   c. Mark with name of manufacturer and specific design and technical data.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads shown on General Structural Notes on Drawings.
2. Manufacturer’s recommendation for installation of system.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials with manufacturer's labels indicating brand name, pattern, size, thickness, and fire rating.

B. Store materials in original protective packaging to prevent soiling, physical damage, or wetting.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Where acoustical materials are to be installed, maintain humidity of 65 percent to 75 percent in area for 25 hours before, during, and 25 hours after installation.

B. Maintain a uniform temperature of 55 degrees F to 70 degrees F during installation of materials.

1.05 EXTRA MATERIAL

A. Provide acoustical units from same production run as installed equal to 1 percent of area.

PART 2 PRODUCTS

2.01 SUSPENSION SYSTEMS

A. Components, Materials, and Accessories: Product of a single manufacturer.

B. ASTM C635/C635M, Intermediate Duty:

1. Exposed Tee Grid: Fire-rated spaced to fit lay-in panels.
   a. Manufacturers and Products:
      1) Chicago Metallic Corp.; Fire Front 1230 System.
      2) Donn Corp.; Donn DXL fire-rated grid.
2. Main and Cross Members:
   a. Double web design, cold-rolled steel, minimum thickness of 0.020 inch, electrozinc-coated and factory-painted low-sheen satin white finish.
   b. Exposed Flange Width: 15/16 inch.
3. Edge Molding:
   a. Minimum 0.020-inch steel, channel- or angle-shaped.
   b. Flange Width: 15/16 inch, minimum.
   c. Finish to match main members.
4. Hanger Wire: ASTM A641/A641M, minimum 12-gauge, galvanized, soft-annealed, mild steel wire.
5. Wire Ties: ASTM A641/A641M, 18-gauge, galvanized, annealed steel wire.

2.02 ACOUSTICAL UNITS

A. Flat Lay-In Panels:

1. Material: Fire-resistive mineral fiber, Class A.
2. In accordance with ASTM E1264, Type III, Form 2.
3. Pattern: Random fissured.
4. Noise Reduction Coefficient (NRC): 0.55 to 0.65.
5. Ceiling Attenuation Class (CAC): 35 minimum.
6. Light Reflectance: LR 0.75 or over.
7. Nominal Size: 24 inches by 48 inches by 5/8 inch thick.
8. Edges: Square.
9. Finish and Color: Painted white, unless scheduled otherwise.
10. Manufacturers and Products:
    a. Armstrong; Item 895, Minaboard, Cortega.
    b. Celotex; Item PBT-197, Hytone, Baroque.
    c. U.S.G.; Item 56705, Auratone, Natural Fissured II.

PART 3 EXECUTION

3.01 SEQUENCING

A. Lay out grid.

B. Coordinate with mechanical and electrical equipment in framing and cutting material around ceiling penetrations.

C. Install suspension systems after mechanical work above is complete.

D. Install acoustical units.

3.02 INSTALLATION OF SUSPENDED GRID SYSTEM

A. Hang level and in straight alignment directly from structure following ASTM C636/C636M and manufacturer’s current printed instructions.

B. Hanger Wires:

1. Space maximum 4 feet on center each direction and securely attach to structure above.
2. Install additional hangers at ends of each suspension member and at light fixtures, 6 inches from vertical surfaces.
3. Do not splay wires more than 5 inches in a 4-foot vertical drop.
4. Provide four-way wire splays at 45 degrees from main runner to support structure for every 144 square feet of ceiling area.
5. Wrap wire minimum three times horizontally, turning ends upward.

6. Where hanger wires cannot be hung vertically from structure above because of ducts, pipes, cable trays, or other interferences, provide steel channel trapezes (minimum 2-inch deep, 16-gauge cold-rolled carrying channels) hung on steel rods or 8-gauge wire from structural members above. Hang ceiling wires from these trapezes or similar members supporting ducts or pipes. Do not hang directly from ducts or pipes.
7. Follow suspension system manufacturer's instructions for modified installation required for Seismic Design Category indicated in General Structural Notes on Drawings.

C. Edge Molding:

1. Install at intersection of suspended ceiling and vertical surfaces.
2. Miter corners where moldings intersect or install corner caps.
3. Attach to vertical surface with mechanical fasteners.

D. Provide additional channels, hangers, and trapezes as required to support edges of ceiling around and under mechanical and electrical work.

3.03 INSTALLATION OF ACOUSTICAL UNITS

A. Upon completion of suspended grid system and other concealed work, install with pattern running in one direction.

B. Place material to bear all around on suspension members.

3.04 CLEANING

A. Clean soiled or discolored unit surfaces after installation.

B. Touch up scratches, abrasions, voids, and other defects in painted surfaces.

3.05 SCHEDULE OF CEILING TYPES

A. Areas to Receive Acoustical Ceilings: As indicated on Interior Finish Schedule located on Drawings and where shown on Drawings.

END OF SECTION

SECTION 09 65 00
RESILIENT FLOORING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   b. D570, Standard Test Method for Water Absorption of Plastics.
   c. E595, Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment.
   d. E648, Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Energy Source.
   e. E662, Test Method for Specific Density of Smoke Generated by Solid Materials.
   f. F970, Test Method for Static Load Limit.
   g. F1861, Standard Specification for Resilient Wall Base.
   h. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
2. National Fire Protection Association (NFPA):
   a. 253, Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Energy Source.
   b. 258, Test Method for Specific Density of Smoke Generated by Solid Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Samples: Two 2-1/2-inch-wide strips of base material proposed for use.

B. Informational Submittals:

1. Manufacturer’s certificate of compliance.
2. Operation and Maintenance Data:
   a. As specified in Section 01 78 23, Operation and Maintenance Data.
   b. List of recommended maintenance products, methods, and procedures.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Store materials in original containers at not less than 70 degrees F ambient temperature for not less than 24 hours immediately before installation.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperature in space to receive flooring between 70 degrees F and 90 degrees F for not less than 24 hours before and 48 hours after installation.

B. Maintain minimum temperature of 55 degrees F after flooring is installed, except as specified above.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Flooring products of the following manufacturers, meeting these Specifications, may be used on this Project:

1. Armstrong World Industries, Inc.
2. Burke Flooring Products.
3. Roppe (base).

2.02 RESILIENT BASE

A. General: ASTM F1861, uniform in 0.125-inch thickness and in as long lengths as practicable to suit conditions of installation.

1. Factory premolded internal and external corners to match base when available. Where resilient base is indicated, use either rubber or vinyl base.
2. Rubber Base: Type TP, Group 1.
3. Vinyl Base: Type TV, Group 1.
4. Style: cove.
5. 4 inches high.

B. Manufacturers and Products:

1. Armstrong; Color-Integrated Wall Base.
2. Johnsonite; Traditional Wall Base.

2.03 ACCESSORIES

A. Adhesive: Type and brands of adhesive as recommended by manufacturer of floor covering material for conditions of installation.

B. Primer and Crack Filler: Type and brand recommended by floor covering manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrate for excessive moisture content and unevenness preventing execution and quality of resilient flooring as specified.

B. Correct defects before installation of resilient flooring.

3.02 PREPARATION

A. Remove dirt, oil, grease, or other foreign matter from surfaces to receive floor covering materials.

B. Prime surfaces, other than wood, if recommended by floor covering manufacturer.

3.03 APPLICATION OF ADHESIVES

A. Mix and apply adhesives in accordance with manufacturer’s instructions.

B. Provide safety precautions during mixing and applications as recommended by adhesive manufacturer.

C. Apply uniformly over surfaces:

1. Cover only amount of area that can be covered by flooring material within recommended working time of adhesive.
2. Remove any adhesive that dries or films over.
3. Do not soil walls, bases, or adjacent areas with adhesives.
4. Promptly remove any spillage.

D. Apply adhesives with notched trowel or other suitable tool.

E. Clean trowel and rework notches as necessary to ensure proper application of adhesive.

3.04 INSTALLATION OF BASE

A. General: Remove defects in wall and floor that would prevent level and true installation of base material.

1. Install base around perimeter of room or space, where shown, and at toe spaces of casework and cabinets.
2. Unroll base material and cut into accurate lengths as desired or as required for minimum number of joints.
3. Match edges at seams or double cut adjoining lengths to give continuous appearance.
4. Install with tight butt joints with no joint widths greater than 1/64 inch.

B. Top-Set Base:

1. Apply adhesive and firmly adhere to wall surfaces.
2. Press down so bottom cove edge follows floor profile.
3. Ensure top and bottom edges of base are in firm contact with walls and floors.
4. Form internal and external corners by using premolded corners. Other methods, acceptable to Engineer, may be used if premolded corners are not available.
5. Scribe base accurately to abutting materials.

3.05 CLEANING AND PROTECTION

A. Upon completion of the installation of floor covering and adjacent work, and after materials have set, clean surfaces with a neutral cleaner as recommended by manufacturer for type of floor covering material installed.

B. Repair adjacent surfaces damaged by flooring installation.

3.06 INSTALLATION SCHEDULE

A. Areas to receive resilient flooring, are indicated in Interior Finish Schedule on Drawings.

END OF SECTION

SECTION 09 66 00
THIN-SET EPOXY TERRAZZO

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Poured in place epoxy terrazzo flooring and integral formed base with joint, edge, and termination strips.

1.02 RELATED SECTIONS

A. Section 03 30 00, Cast-in-Place Concrete.

B. Section 07 91 01, Sealants and Caulking.

C. Section 09 29 01, Gypsum Board Assemblies.

1.03 REFERENCES

A. NTMA: National Terrazzo and Mosaic Association.

B. ASTM International (ASTM):
1. ASTM C24l, Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic.
2. ASTM D56, Standard Test Method for Flash Point by Tag Closed Cup Tester.
3. ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
4. ASTM D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
5. ASTM D695, Standard Test Method for Compressive Properties of Rigid Plastics.
6. ASTM D696, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 degree C and 30 degree C With a Vitreous Silica Dilatometer.
7. ASTM D1308, Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes.
8. ASTM D2240, Standard Test Method for Rubber Property-Durometer Hardness.
9. ASTM F1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
10. ASTM F2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes.

C. ACI Committee No. 403 Bulletin Title No.59.

1.04 SUBMITTALS

A. Submit under provisions of Section 01 33 00, Submittal Procedures.

B. Manufacturer's data sheets on each product to be used, including:

1. Manufacturers Application Instructions: Submit descriptive data and specific recommendations for mixing, application, curing including any precautions of special handling instructions required to comply with the Occupational Safety and Health Act.
2. Preparation instructions and recommendations.
3. Storage and handling requirements and recommendations.

C. Shop Drawings: Shop Drawings shall be furnished showing installation of cove base and termination detail, and details at floor material transitions and abutting adjoining equipment.

1. Locate and provide detailing for flexible joints required of flooring in area of installation.
2. Installer to verify locations of all flexible joints required by the provisions of this section and by the recommendations of the related material manufacturers.
   a. Joint locations are required whether shown or not in Contract Drawings.

D. Selection Samples: For each finish product specified.

1. Submit maximum of three samples, 6 inches by 6 inches for each color and type of terrazzo available from manufacturer's full range.
2. Submit two 6-inch lengths of each type and kind of divider strips available.

E. Verification Samples: For each finish product specified.

1. Submit maximum of three samples, 6 inches by 6 inches for each color and type of terrazzo as specified.
2. Submit two 6-inch lengths of each type and kind of divider strips as specified.

F. Maintenance Literature: Submit two copies of NTMA and/or manufacturer's maintenance recommendations.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Manufacturer shall provide materials in accordance with NTMA standards.
2. Materials used in the floor surfacing shall be the products of a single manufacturer.

B. Installer Qualifications:

1. Acceptable installer shall be a contractor member of the NTMA to perform all work in accordance with NTMA standards.
2. If installer is not a contractor member of the NTMA, he shall submit a list of completed projects of similar magnitude and complexity.
3. Installer shall be acceptable to Architect and manufacturer.
4. Installation shall be performed by an applicator with minimum 3-years' experience in work of similar nature and scope. Installer shall be approved by the manufacturer of the floor surfacing materials. The Contractor shall furnish a written statement from the manufacturer that the installer is acceptable.
5. Contractor to have proven experience with specified system.
6. Mock-up: Prior to starting application of flooring, provide full scale portable mock-up to establish acceptable quality, durability, and appearance.

C. Certification:

1. Manufacturer shall furnish certification attesting that materials meet specification requirements.
2. Manufacturer shall furnish properly labeled material and Material Safety Data Sheets which comply to current state and federal requirements.
3. Manufacturer shall submit certification that installer is an approved applicator of material selected.

D. Pre-Construction Meeting: Pre-job meeting between Contractor, Architect, and installer shall be held to discuss concrete substrate, location of joints and/or saw cuts to minimize sub-floor cracking and locations of control joints and strips in terrazzo surface.

E. Mock-Up: Provide an installed mock-up for evaluation of surface preparation techniques and application workmanship.

1. Finish areas designated by Engineer.
2. Mock-up size shall not be less than 50 square feet.

3. Acceptable mock-up to be standard of quality for installed work.
4. Unacceptable installed work to be removed and replaced or refinished until acceptable.

1.06 DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered to project site in original manufacturer's sealed containers including type of material, batch numbers, date of manufacture, and pertinent labels intact and legible.

B. Store materials in dry protected area at a temperature between 50 degree F (10 degrees C) and 80 degree F (27 degrees C).

C. Follow all manufacturer's specific instructions and prudent safety practices for storage and handling.

D. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.07 PROJECT CONDITIONS

A. Maintain the ambient room and floor temperature at 60 degree F (15 degrees C) or above for a period extending from 72 hours before, during and after floor installation. Concrete to receive surfacing shall have cured for at least 28 days and be free of all curing compounds.

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

1.08 WARRANTY

A. Five years from date of completion of terrazzo installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Key Resin Co; Key Epoxy Terrazzo.

B. DEX-O-TEX; Spectrum Terrazzo.

C. Requests for substitutions will be considered in accordance with provisions of Division 1, General Requirements.

2.02 MATERIALS

A. Primer: Only as recommended by the manufacturer.

B. Epoxy resin mixed according to manufacturer's recommendation and tested without aggregate added. All specimens cured for 7 days at 75 degrees F (24 degrees C) plus or minus 2 degrees F and 50 percent plus or minus 2 percent R.H. The product shall meet the following requirements:

1. Hardness ASTM D2240 using 60-85. Shore D Durometer
2. Tensile Strength Specimen made using 3,000 psi (21 MPa) minimum.
3. "C" die listed in ASTM D412 Compressive ASTM D695, 10,000 psi (70 MPa) minimum. Strength Specimen B cylinder
4. Chemical Resistance ASTM D1308: 7 days at room temperature by immersion method have no deleterious effects.
5. The following contaminants tested: Distilled Water 1 percent Soap Solution; Mineral Oil 10 percent Sodium Hydroxide; Isopropanol 10 percent Hydrochloric Acid; Ethanol 30 percent Sulfuric Acid; .025 Detergent Solution
6. Bond Strength: When tested in accordance with Field Test Method for surface soundness and adhesion as described in ACI Committee No. 403 Bulletin Title No. 59-43 (Pages 1139-1141) the Epoxy Terrazzo shall comply with the following value: 100 percent concrete failure minimum, with 300 psi (2.1 MPa) minimum tensile strength.

C. Epoxy Resin mixed according to manufacturers recommendations and blended with 3 volumes of Georgia White marble blended 60 percent No. 1 chip and 40 percent No. 0 chip, ground and grouted with epoxy resin. Finishing to a nominal l/4 inch (6 mm) thickness. All specimens cured for 7 days at 75 degrees F (24 degrees C) plus or minus 2 degrees F and 50 percent plus or minus 2 percent R.H. The finished epoxy terrazzo shall meet the following requirements.

1. Flammability: When tested in accordance with ASTM D635, the Epoxy Terrazzo shall comply with the following value: Self-extinguishing, extent of burning .025 inches (.64 mm) maximum.
2. Thermal Coefficient of Linear Expansion: When tested in accordance with ASTM D696, the Epoxy terrazzo will comply with the following value: 25 by 10-6 inches per inch per degree to 140 degrees F (64 by 10-7 mm per mm per degree to 60 degrees C).

D. Marble Chips or Glass Aggregate:

1. Size: To conform to NTMA gradation standards.
2. Hardness according to ASTM C24l Ha-10 minimum.
3. 24 hours absorption rate not to exceed 0.75 percent.
4. Chips shall contain no deleterious or foreign matter.
5. Dust content less than 1 percent by weight.

E. Strips: Stop and divider zinc "L" strips.

F. Terrazzo Cleaner:

1. pH factor between 7 and 10.
2. Biodegradable and phosphate free.

G. Sealer:

1. pH factor between 7 and 10.
2. Sealer shall not discolor or amber.
3. Flash Point: ASTM D56, 80 degrees F (27 degrees C) minimum.
4. Special stain and/or chemical resistant sealers shall be used for areas requiring resistance to iodine or Betadine.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive terrazzo for:

1. Defects in existing work that affect proper execution of terrazzo work.
2. Deviations beyond allowable tolerances for the concrete slab work.

B. Do not begin installation until substrates have been properly prepared.

C. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 PREPARATION

A. Prepare substrate to receive epoxy terrazzo in accordance with manufacturer's recommendations.

B. Acceptable Substrates:

1. Level tolerance: Concrete sub-floor shall be level with a maximum variation from level of 1/4 inch (6 mm) in 10 feet (3,048 mm). Any irregularity of the surface requiring patching and/or leveling shall be done using material approved by the manufacturer.
2. Concrete floor shall have a steel trowel finish.
3. Concrete shall be cured a minimum of 28 days. No curing agents shall be used in areas to receive terrazzo.
4. Concrete slab shall have an efficient moisture barrier of minimum 10 mils (.2540 mm) placed directly under the concrete slab. Do not use vapor barrier manufactured with recycled content. Testing shall be done to verify that the moisture vapor emission rate of the slab does not exceed that as recommended by the manufacturer at time of installation of the epoxy terrazzo flooring. Moisture vapor emission and moisture content testing shall conform with the requirements of ASTM F1869 (Calcium Chloride Test) and ASTM F2170 (Relative Humidity Probe Test). If test results show excessive levels of moisture content or vapor emission rate above that recommended by the manufacturer, apply manufacturer's recommended moisture vapor emission control material.
5. Saw cutting of control joints shall be done between 12 and 24 hours after placement of the structural concrete.

C. Clean surfaces thoroughly prior to installation.

D. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

E. Cast-in-Place Concrete:

1. Shotblast or rough grind area to receive terrazzo according to manufacturer's recommendations.
2. Refer to NTMA Technical Bulletin No. 111 or NTMA.com "Crack Detailing and Joint Treatments for Thin Set Terrazzo". Route out all cracks larger than 1/32-inch (0.8 mm) width and fill with rigid epoxy. Apply flexible Epoxy across the crack a minimum width of 24 inches (610 mm) at a spread rate of 50 square feet (4.6 square meters) per gallon to achieve 32 mils (.8128 mm) dry over the crack and allow to cure. Apply primer to cured membrane. Imbed fiberglass mesh into wet primer and saturate with additional primer.

3. Apply Flexible Epoxy over entire floor surface as a crack isolation membrane if cracks are numerous.
4. Install divider strips directly above control joints, cold joints and expansion joints in sub floor.
5. Install divider strips as shown on Drawings.

3.03 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Locate all flexible joints required.

C. Provide accessories necessary for complete installation.

D. Backing for epoxy terrazzo base shall be a cement board, concrete block, concrete or cement plaster.

E. Sufficient water, temporary heat, light and adequate electrical power with suitable outlets connected and distributed for use within 100 feet (30 m) of any working space.

F. Placing Terrazzo:

1. Prime subfloor in accordance with resin manufacturer's instructions.
2. Place terrazzo mixture and trowel to a dense flat surface to top of divider strips.

G. Finishing:

1. Rough Grinding:
   a. Grind with 24 or finer grit stones or with comparable diamond plates.
   b. Follow initial grind with 80 or finer grit stones.
2. Grouting:
   a. Cleanse floor with clean water and rinse.
   b. Remove excess rinse water, dry, and apply epoxy grout, supplied by epoxy manufacturer, to fill voids.
3. Cure Grout.
4. Fine Grinding:
   a. Grind with 80 or finer grit stones until all grout is removed from surface.
   b. Upon completion, terrazzo shall show a minimum of 70 percent marble chips.

3.04 CLEANING AND SEALING

A. Wash all surfaces with a neutral cleaner.

B. Rinse with clean water and allow surface to dry.

C. Apply sealer in accordance with manufacturer's directions.

3.05 PROTECTION

A. Upon completion, the work shall be ready for final inspection and acceptance by the owner or his agent.

3.06 PROTECTION

A. The Contractor shall protect the finished floor from the time that the terrazzo installer completes the Work.

B. Protect installed products until completion of Project.

C. Touchup, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 09 67 00
FLUID-APPLIED FLOORING

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Manufacturer's product specifications.
2. Samples: Two 6-inch square Samples of color and finish selected.

B. Informational Submittals:

1. Evidence of installer's approval by manufacturer.
2. Manufacturer's installation instructions.

1.02 QUALITY ASSURANCE

A. Qualifications of Installer:

1. Minimum of 5 years' experience in installing seamless flooring of similar size and materials.
2. Approved by manufacturer of the flooring products.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in their original, unopened containers, clearly labeled with manufacturer's name, brand name, and such identifying numbers as are appropriate.

B. Store materials at temperatures between 60 degrees F and 80 degrees F. Should they be exposed to lower temperatures, restore to 60 degrees F prior to use.

C. Protect materials against wetting, moisture absorption, and construction traffic.

1.04 EXTRA MATERIALS

A. Provide minimum 2 gallons of unopened top coating material for future use by Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Crossfields Products Corp.; Dex-O-Tex DecorFlor.
2. Dur-A-Flex, Inc.; Dur-A-Quartz.
3. Florock; Floroquartz IV.
4. Stonhard; Stonshield SLT.
5. Selby, Battersby & Co.; Selbatwede 71.

2.02 MATERIALS

A. Floor Covering and Cove Base Epoxy: 100 percent solids, thermosetting epoxy resins reacted with suitable hardeners to produce a seamless, monolithic, plastic coating.

B. Aggregate: Quartz (silicon dioxide) base rock granules fired with a colored ceramic coating as manufactured by:

1. 3M; Colorquartz Brand.
2. Stonhard, Inc.

C. Edge or Divider Strips: Standard products manufactured or approved by floor covering manufacturer for use with seamless covering material used.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine surfaces scheduled to receive seamless covering for all defects, dampness, paint, or foreign material that would affect the quality and execution of the Work.

B. Perform moisture or adhesion tests as recommended by manufacturer.

C. Make corrections necessary to provide surfaces acceptable to manufacturer.

3.02 PREPARATION

A. Clean concrete surfaces of foreign material, sealers, hardeners, waxes and other curing compounds, laitance, and grease.

B. Prepare concrete by mechanical means, including use of a scabbler, scarifier, or shot blast machine, for removal of bond inhibiting materials, such as curing compounds and laitance. Acid etching is not an acceptable method of preparation.

C. Apply primer to surfaces as required by flooring material manufacturer.

3.03 INSTALLATION

A. Install seamless floor covering following manufacturer's instructions and recommendations.

B. Apply to floor and base in minimum thickness permitted by aggregate, approximately 3/32 inch.

C. Finish glossy and slip resistant.

D. Install at locations indicated in Interior Finish Schedule.

3.04 PROTECTION

A. During installation, protect adjacent surfaces against damage.

B. After installation, allow no traffic on seamless finish for 48 hours or until completely cured.

C. Keep water off floor for at least 5 days.

D. Do not cover with paper until it will not stick. Use only nonstaining paper.

END OF SECTION

SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.
   b. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   c. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   d. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
5. Occupational Safety and Health Act (OSHA).
6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.
7. The Society for Protective Coatings (SSPC):
   a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   b. PA 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
   c. SP 1, Solvent Cleaning.
   d. SP 2, Hand Tool Cleaning.
   e. SP 3, Power Tool Cleaning.
   f. SP 5, White Metal Blast Cleaning.
   g. SP 6, Commercial Blast Cleaning.
   h. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
   i. SP 10, Near-White Blast Cleaning.
   j. SP 11, Power Tool Cleaning to Bare Metal.
   k. SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   l. SP 13, Surface Preparation of Concrete.

m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
6. Mil: Thousandth of an inch.
7. PDS: Product Data Sheet.
8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Data Sheets:
      1) For each product, furnish a Product Data Sheet (PDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PDS form is appended to the end of this section.
      2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
      3) Technical and performance information that demonstrates compliance with specification.
      4) Furnish copies of paint system submittals to the coating applicator.
      5) Indiscriminate submittal of only manufacturer's literature is not acceptable.
   b. Detailed chemical and gradation analysis for each proposed abrasive material.
2. Samples:
   a. Proposed Abrasive Materials: Minimum 5-pound sample for each type.

b. Reference Panel:
   1) Surface Preparation:
      a) Prior to start of surface preparation, furnish a 4-inch by 4-inch steel panel for each grade of sandblast specified herein, prepared to specified requirements.
      b) Provide panel representative of the steel used; prevent deterioration of surface quality.
      c) Panel to be reference source for inspection upon approval by Engineer.
   2) Paint:
      a) Unless otherwise specified, before painting work is started, prepare minimum 8-inch by 10-inch sample with type of paint and application specified on similar substrate to which paint is to be applied.
      b) Furnish additional samples as required until colors, finishes, and textures are approved.
      c) Approved samples to be the quality standard for final finishes.

B. Informational Submittals:

1. Applicator's Qualification: List of references substantiating experience.
2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
4. Manufacturer's written verification that submitted material is suitable for the intended use.
5. Coating for Faying Surfaces: Manufacturer's test results that show the proposed coating meets the slip resistance requirements of the AISC Specification for Structural Joints using ASTM A325 or ASTM A490 bolts.
6. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
7. Manufacturer's written instructions and special details for applying each type of paint.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

B. Regulatory Requirements:

1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.

2. Perform surface preparation and painting in accordance with recommendations of the following:
   a. Paint manufacturer's instructions.
   b. SSPC PA 10.
   c. Federal, state, and local agencies having jurisdiction.

C. Mockup:

1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.
2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

B. Status of Existing Coatings: The following information on existing coatings or substrate conditions is provided for information only, and is generally believed to be accurate, but is not guaranteed. Perform tests as required to verify applicability of this information to the Work.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. TNEMEC.
2. Or approved equal.

2.02 ABRASIVE MATERIALS

A. Select abrasive type and size to produce surface profile that meets coating manufacturer's recommendations for specific primer and coating system to be applied.

2.03 PAINT MATERIALS

A. General:

1. Manufacturer's highest quality products suitable for intended service.
2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products:

Product	Definition
Acrylic Latex	Single-component, finish as required
Acrylic Latex (Flat)	Flat latex
Acrylic Sealer	Clear acrylic
Alkyd (Semigloss)	Semigloss alkyd
Alkyd Enamel	Optimum quality, gloss or semigloss finish as required, medium long oil

Product	Definition
Alkyd Wood Primer	Flat alkyd
Bituminous Paint	Single-component, coal-tar pitch based
Block Filler	Primer-sealer designed for rough masonry surfaces, 100% acrylic emulsion
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
DTM Acrylic Primer	Surface tolerant, direct-to-metal water borne acrylic primer
DTM Acrylic Finish	Surface tolerant, direct-to-metal water borne acrylic finish coat
Elastomeric Polyurethane	100% solids, plural component, spray applied, high build, elastomeric polyurethane coating, suitable for the intended service
Epoxy Filler/Surfacer	100% solids epoxy trowel grade filler and surfacer, nonshrinking, suitable for application to concrete and masonry. Approved for potable water contact and conforming to NSF 61, where required
Epoxy Nonskid (Aggregated)	Polyamidoamine or amine converted epoxies aggregated; aggregate may be packaged separately
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated
Fusion Bonded Coating	100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service
TFE Lube or Grease Lube	Tetrafluoroethylene, liquid coating, or open gear grease as supplied by McMaster-Carr Supply Corporation, Elmhurst, IL
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Inorganic Zinc Primer	Solvent or water based, having 85% metallic zinc content in the dry film; follow manufacturer's recommendation for topcoating

Product	Definition
Latex Primer Sealer	Waterborne vinyl acrylic primer/sealer for interior gypsum board and plaster. Capable of providing uniform seal and suitable for use with specified finish coats
NSF Epoxy	Polyamidoamine epoxy, approved for potable water contact and conforming to NSF 61
Epoxy, High Solids	Polyamidoamine epoxy, 80% volume solids, minimum, suitable for immersion service
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish
Organic Zinc Rich Primer	Epoxy or moisture cured urethane with 85-percent zinc content in the dry film, meeting the requirements of RCSC Specification for Structural Joints using High Strength Bolts, Class A or Class B, as required.
Rust-Inhibitive Primer	Single-package steel primers with anticorrosive pigment loading
Sanding Sealer	Co-polymer oil, clear, dull luster
Silicone/Silicone Acrylic	Elevated temperature silicone or silicone/acrylic based
Stain, Concrete	Acrylic, water repellant, penetrating stain
Stain, Wood	Satin luster, linseed oil, solid or transparent as required
Varnish	Nonpigmented vehicle based on a variety of resins (alkyd, phenolic, urethane) in gloss, semigloss, or flat finishes, as required
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required

2.04 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.

5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.05 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph, Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
   b. The surface preparation and application of the primer shall be performed by pipe manufacturer.
   c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
   d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
   e. For conventional (alkyd) coatings, clean asphalt varnish supplied on pipe and apply one full coat of a tar stop before two full coats of the color coats specified.

2. Steel Pipe:
    a. Surface preparation and application of primer shall be performed by pipe manufacturer.
    b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer's recommendations, the more stringent shall apply.

B. Surface Contamination Testing:

1. A surface contamination analysis test shall be performed every 500 square feet by means of a Chlor Test CSN Salts or approved equivalent.
2. Surface with chloride levels exceeding 3 µg/square centimeter for submerged surfaces and 5 µg/square centimeter for exposed surfaces shall be treated with a liquid soluble salt remover equivalent to CHLOR*RID (CHLOR*RID International, Chandler, AZ).
3. Follow manufacturer's recommendations and procedures for the use of this product to remove the surface contamination.

C. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
   a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
   b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.
   c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
   d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.

e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.

g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.

i. SP-16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).

2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.

6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
   a. Prepare such that there is:
      1) No undercutting or reverse ridges on weld bead.
      2) No weld spatter on or adjacent to weld or any area to be painted.
      3) No sharp peaks or ridges along weld bead.
   b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
   a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
   b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
   c. Clean small isolated areas as above or solvent clean with suitable solvent and clean cloth.
9. Blast Cleaning Requirements:
   a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer's recommendations.
   b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
   c. Use only dry blast cleaning methods.
   d. Do not reuse abrasive, except for designed recyclable systems.
   e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
10. Post-Blast Cleaning and Other Cleaning Requirements:
   a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
   b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

D. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.

2. Brush blast in accordance with SSPC SP 16.
3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

E. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.
5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

F. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

G. Masonry Surface Preparation:

1. Complete and cure masonry construction for 14 days or more before starting surface preparation work.
2. Remove oil, grease, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent washing, or other suitable cleaning methods.
3. Clean masonry surfaces of mortar and grout spillage and other surface deposits using one of the following:
   a. Nonmetallic fiber brushes and commercial muriatic acid followed by rinsing with clean water.
   b. Brush-off blasting.
   c. Water blasting.
4. Do not damage masonry mortar joints or adjacent surfaces.
5. Leave surfaces clean and, unless otherwise required for proper adhesion, dry prior to painting.

6. Masonry Surfaces to be Painted: Uniform texture and free of surface imperfections that would impair intended finished appearance.
7. Masonry Surfaces to be Clear Coated: Free of discolorations and uniform in texture after cleaning.

H. Wood Surface Preparation:

1. Replace damaged wood surfaces or repair in a manner acceptable to Engineer prior to start of surface preparation.
2. Solvent clean (mineral spirits) knots and other resinous areas and coat with shellac or other knot sealer, prior to painting. Remove pitch by scraping and wipe clean with mineral spirits or turpentine prior to applying knot sealer.
3. Round sharp edges by light sanding prior to priming.
4. Filler:
    a. Synthetic-based wood putty approved by paint manufacturer for paint system.
    b. For natural finishes, color of wood putty shall match color of finished wood.
    c. Fill holes, cracks, and other surface irregularities flush with surrounding surface and sand smooth.
    d. Apply putty before or after prime coat, depending on compatibility and putty manufacturer's recommendations.
    e. Use cellulose type putty for stained wood surfaces.
5. Ensure surfaces are clean and dry prior to painting.

I. Gypsum Board Surface Preparation: Typically, new gypsum board surfaces need no special preparation before painting.

1. Surface Finish: Dry, free of dust, dirt, powdery residue, grease, oil, or any other contaminants.

J. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.

7. Application of Cosmetic Coat:
    a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
    b. Check compatibility by application to a small area prior to starting painting.
    c. If lifting or other problems occur, request disposition from Engineer.
8. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can: One part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
    a. Rate: Approximately 2 gallons per 100 square feet.
    b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
    c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
    d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
    e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
    f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for existing as noted and new, interior and exterior wood, masonry, concrete, metal, and submerged metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise. Do not paint exterior concrete surfaces, unless specifically indicated.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.
3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer's written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these Specifications and paint manufacturers' printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Sand wood lightly between coats to achieve required finish.
6. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
7. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.
8. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
9. Water-Resistant Gypsum Board: Use only solvent type paints and coatings.
10. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
11. Keep paint materials sealed when not in use.
12. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, Such As Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
   a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
   a. Minimum required without regard to coating thickness.
   b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
   a. Do not exceed coating manufacturer's recommendations.
   b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
   a. Perform with properly calibrated instruments.
   b. Recoat and repair as necessary for compliance with specification.
   c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. As shown on Drawings.

C. System No. 1 Submerged Metal—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	NSF Epoxy	3 coats, 3 MDFTPC

1. Use on the following items or areas:
   a. Metal surfaces new and existing (noted on Drawings) below a plane 1 foot above the maximum liquid surface; metal surfaces above the maximum liquid surface that are a part of the immersed equipment; surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel that are embedded in concrete; and the following specific surfaces:
      1) Interior surfaces of steel piping noted in the Piping Schedule.

D. System No. 2 Submerged Metal—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Prime in accordance with manufacturer's recommendations	
	Coal-Tar Epoxy -OR- High Build Epoxy	2 coats, 16 MDFT 2 coats, 16 MDFT

1. Use on the following items or areas:
   a. Metal surfaces new and existing (noted on Drawings) below a plane 1 foot above maximum liquid surface, metal surfaces above maximum liquid surface that are a part of immersed equipment, concrete embedded surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel, and the following specific surfaces:
      1) Interior surfaces of steel piping noted in the Piping Schedule.

E. System No. 3 Submerged Metal—Other:

1. Use on the following items or areas:
   a. Metal surfaces new and existing (noted on Drawings) below a plane 1 foot above maximum liquid surface, metal surfaces above maximum liquid surface which are a part of immersed equipment, and the following specific surfaces:
      1) Interior surfaces of steel piping noted in the Piping Schedule.

F. System No. 4 Exposed Metal—Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	High Build Epoxy	1 coat, 4 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing (noted on Drawings) located inside or outside of structures and exposed to weather

G. System No. 5 Exposed Metal—Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing (noted on Drawings) located inside or outside of structures and exposed to weather or in a highly humid atmosphere, such as pipe galleries and similar areas**.**

H. System No. 6 Exposed Metal—Atmospheric:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Rust-Inhibitive Primer	1 coat, 2 MDFT
	Alkyd Enamel	2 coats, 4 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing (noted on Drawings) located inside or outside of structures or exposed to weather, including metal doors and frames, vents, louvers, exterior metal ductwork, flashing, sheet metalwork and miscellaneous architectural metal trim and the following specific surfaces:
      1) Inside duct stack heads behind diffusers, registers, and grilles with flat black.
      2) Instrumentation and control systems exposed enclosures for process.
   b. Apply surface preparation and primer to surfaces prior to installation. Finish coats need only be applied to surfaces exposed after completion of construction.

I. System No. 7 Concrete Encased Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Coal-Tar Epoxy	2 coats, 16 MDFT
	High Build Epoxy	

1. Use on the following items or areas:
   a. Use on concrete encased ferrous metals including wall pipes, pipe sleeves, access manholes, gate guides, and thimbles.

J. System No. 8 Buried Metal—General:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Standard Hot Coal-Tar Enamel -OR- Coal-Tar Epoxy	AWWA C203 2 coats, 16 MDFT
	For Highly Abrasive Soil, Brackish Water: Tape Coat System	AWWA C214 with Double Outer Wrap

1. For steel pipe and fittings, follow AWWA C209 and AWWA C214 with double outer wrap**.**
2. Use on the following items or areas:
   a. Buried, below grade portions of steel items, except buried stainless steel or ductile iron**.**

K. System No. 9 Special Coatings—Metal: Not Used

L. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer—Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on the following items or areas:
   a. Galvanized surfaces requiring painting.
   b. After application of System No. 10, apply finish coats as required for exposure.

M. System No. 11 Faying Surfaces of Slip Critical Bolted Connections:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Organic Zinc Rich Primer	1 coat, 3 MDFT

1. Use on faying surfaces of slip critical joints as specified and as shown on Drawings.
2. Provide primer in accordance with RCSC Specification for Structural Joints using High-Strength Bolts.

N. System No. 12 Skid-Resistant—Steel:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT

1. Use on the following items or areas:
   a. As noted on the Drawings and in the Specifications.

O. System No. 13 Skid-Resistant—Aluminum and FRP:

Surface Prep.	Paint Material	Min. Coats, Cover
Aluminum: In accordance with Article Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation -OR- FRP: In accordance with Article Plastic and FRP Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT

1. Use on the following items or areas:
   a. As noted on the Drawings and in Specifications

P. System No. 14 High Heat-Resistant—700 Degrees F Maximum:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Inorganic Zinc Primer	1 coat, 2.5 MDFT
	Silicone	1 coat, 2 MDFT

1. Use on the following items or areas:
   a. As noted on the Drawings and in Specifications

Q. System No. 15 Heat-Resistant—425 Degrees F Maximum:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Inorganic Zinc Primer	1 coat, 2.5 MDFT
	Silicone Acrylic (limited colors)	2 coats, 2 MDFT

1. Use on the following items or areas:
   a. As noted on the Drawings and in Specifications

R. System No. 17 Special Coating—Concrete:

1. Use on the following areas:
   a. As noted on the Drawings and in Specifications

S. System No. 18 Concrete Tank Lining—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Filler/Surfacer (NSF-approved)	As required to fill voids and level surface
	NSF Epoxy	3 coats, 250 SFPGPC

1. Use on the following items or areas:
   a. Concrete surfaces below a plane 1 foot above maximum liquid surface
   b. As noted on the Drawings and in Specifications.

T. System No. 18a Concrete Exposed Metal Repair Coating—Potable Water and Non-Submerged:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush blast concrete in accordance with Paragraph Concrete Surface Preparation; blast exposed reinforcing steel to Near White Metal, SSPC SP10. See Note 1	NSF Epoxy; finish color white	2 coats, 4 MDFTPC, see Note 2.
Note 1. Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SSPC SP-11. Note 2. Brush out surface voids and irregularities to provide a monolithic film.		

1. Use this system:
   a. On saw-cut concrete surfaces that will not receive new concrete to cover exposed ends of rebar and metal embeds. Or alternately, where approved, over ends of and minimum 2 inches around ends of exposed metal and rebar in lieu of entire surface.

U. System No. 19 Concrete Tank Lining—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Filler/Surfacer	As required to fill voids and level surface
	Epoxy, High Solids	3 coats, 250 SFPGPC

1. Use on the following items or areas:
   a. Concrete surfaces below a plane 1 foot above maximum liquid surface.

V. System No. 19a Concrete Exposed Metal Repair Coating—Wastewater:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush blast concrete in accordance with Paragraph Concrete Surface Preparation; blast exposed reinforcing steel to Near White Metal, SSPC SP10. See Note 1.	Amine-cured epoxy, suitable for exposure to primary wastewater, finish color gray.	2 coats, 8 MDFTPC, see Note 2.
Note 1. Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SSPC SP-11. Note 2. Brush out surface voids and irregularities to provide a monolithic film.		

1. Unless otherwise noted on saw-cut concrete surfaces that will not receive new concrete to cover exposed ends of rebar and metal embeds. Or alternately, where approved, over ends of and minimum two inches around ends of exposed metal and rebar in lieu of entire surface.

W. System No. 20 Concrete Tank Lining—Other:

1. Use on the following items or areas:
   a. Concrete surfaces below a plane 1 foot above maximum liquid surface.

X. System No. 21 Skid-Resistant—Concrete:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 160 SFPG

1. Use on the following items or areas:
   a. As noted on the Drawings and in Specifications.

Y. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex Semigloss	2 coats, 320 SFPGPC

1. Use on the following items or areas:
   a. All exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.

Z. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on aluminum surfaces embedded or in contact with concrete:
   a. As shown on Drawings or as specified**.**

AA. System No. 29 Fusion Bonded Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Fusion Bonded Coating 100% Solids Epoxy	1 or 2 coats, 7 MDFT

1. For steel pipe and fittings, meet all requirements of AWWA C213.

BB. System No. 29A Fusion Bonded, Steel Dowel Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Fusion Bonded Coating 100% Solids Epoxy	1 or 2 coats, 7 MDFT
TFE Lube, Shop Applied; Grease Lube Alternative, Field Applied Just Prior to Installation	TFE Lube or Grease Lube	1 coat, as required

1. Use on steel expansion joint dowels as specified in Section 03 15 00, Concrete Joints and Accessories.

CC. System No. 30 Moisture-Cure Polyurethane

DD. System No. 31 Direct-to-Metal Acrylic

3.08 ARCHITECTURAL PAINT SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. System No. 106 Galvanized Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Manufacturer's Recommended Primer	1 coat, as recommended by manufacturer
	Alkyd Enamel (Semigloss)	2 coats, 4 MDFT

1. Use on the following items or areas:
   a. Interior Hollow metal Door frames.

C. System No. 109 Masonry, Semigloss:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Masonry Surface Preparation	Block Filler	1 coat, 75 SFPG
	Acrylic Latex (Semigloss)	2 coats, 240 SFPGPC

1. Use on the following items or areas:
   a. Existing CMU interior walls of the RAS-WAS Pump Station Building.

D. System No. 114 Gypsum Board and Plaster, Flat:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Gypsum Board Surface preparation	Latex Primer Sealer	1 coat, 350 SFPG
	Acrylic Latex (Flat)	2 coats, 240 SFPGPC

1. Use on the following items or areas:
   a. Interior walls of the Lab Building and gypsum board ceilings in the Lab Building.

3.09 COLORS

A. Provide as shown for equipment and appurtenances and designated herein and as selected by Owner or Engineer.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint equipment and piping one color as selected.
3. Paint non-submerged portions of equipment the same color as the piping it serves, except as itemized below:
   a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
   b. Fire Protection Equipment and Apparatus: OSHA Red.
   c. Radiation Hazards: OSHA Purple.
   d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

D. Pipe Identification Painting:

1. Color code non-submerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: As shown in table below.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.

4. Pipe Supports: Painted light gray, as approved by Owner and/or Engineer.
5. Fiberglass reinforced plastic (FRP) pipe, polyvinylidene fluoride (PVDF), and polyvinyl chloride (PVC) pipe located inside of buildings and enclosed structures will not require painting, except as noted.

E. Pipe System Color Code:

Pipe System	Color
Air, Process	Federal Safety Green
Air, Instrument	Federal Safety Purple
Ammonia, Liquid	Federal Safety Orange
Ammonia, Solution	Federal Safety Orange
Alum	Dark Green
Chlorine, Gas	Federal Safety Yellow
Chlorine, Liquid	Federal Safety Yellow
Chlorine, Residual Sampling	Silver/Gray
Chlorine Solution	Federal Safety Yellow
Chlorine Ejector Water	Silver/Gray
Chlorine Vent	Federal Safety Yellow
Compressed Air	Federal Safety Purple
Carbon	Black
Drains and Sludge	Light Brown
Decant	Light Brown
Dewatering	Black
Drains	Black
Effluent, Final	Silver/Gray
Effluent, Primary	Silver/Gray
Effluent, Flushing Water, High Pressure	Dark Green
Effluent, Flushing	Dark Green
Fuel Oil Supply	Federal Safety Orange
Fuel Oil Return	Federal Safety Orange
Flocculation Basin Influent	Buff

Pipe System	Color
Filter Backwash Supply	Medium Blue
Filter Surface Wash Supply	Medium Blue
Hot Flushing Loop	Federal Safety Blue
Headworks	Buff
Lime	White
Mixed Liquor	Silver/Gray
Overflow	Silver/Gray
Plant Service Water	Medium Blue
Potable Water	Light Blue
Polymer/Cationic	Buff
Polymer Nonionic or Anionic	Buff
Raw Sewage	Dark Gray
Rapid Mix Influent	Light Brown
Scum	Light Brown
Sample	Medium Green
Seal Water	Federal Safety Blue
Sludge, Digested	Dark Brown
Sludge, Primary	Dark Brown
Sludge, Return Activated	Light Brown
Sludge, Thickened	Light Brown
Sludge, Waste Activated	Dark Brown
Sludge, Stored	Dark Brown
Sludge, Recirculated	Dark Brown
Sludge, Mixed	Light Brown
Thickener Dilution Water	Dark Green

3.10 FIELD QUALITY CONTROL

A. Testing Equipment:

1. Provide calibrated electronic type dry film thickness gauge to test coating thickness specified in mils.

2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.
3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.

B. Testing:

1. Thickness and Continuity Testing:
   a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
   b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
   c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
   d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

C. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.

D. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
3. Repair defects in accordance with written recommendations of coating manufacturer.

E. Damaged Coatings, Pinholes, and Holidays:

1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.

2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.11 MANUFACTURER'S SERVICES

A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. A minimum of two additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.12 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.13 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Paint System Data Sheet (PSDS).
2. Product Data Sheet (PDS).

END OF SECTION

PAINT SYSTEM DATA SHEET

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	**Product Name/Number (Proprietary)**	**Min. Coats, Coverage**

PAINT PRODUCT DATA SHEET

Complete and attach manufacturer's Technical Data Sheet to this PPDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio: .

Maximum Permissible Thinning:_____

Ambient Temperature Limitations: min.:_____ max.:_____

Surface Temperature Limitations: min.:_____ max.:_____

Surface Profile Requirements: min. :_____ max.:_____

Attach additional sheets detailing manufacturer's recommended storage requirements and holiday testing procedures.

SECTION 10 14 00
SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
2. ASTM International (ASTM):
   a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   b. D709, Standard Specification for Laminated Thermosetting Materials.
3. International Code Council (ICC):
   a. A117.1, Accessible and Usable Buildings and Facilities.
   b. International Fire Code (IFC): Chapter 27, Hazardous Materials-General Provisions.
4. National Fire Protection Association (NFPA):
   a. 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.
   b. HAZ-01, Fire Protection Guide to Hazardous Materials.
5. Occupational Safety and Health Act (OSHA).
6. U.S. Department of Transportation, Federal Highway Administration: Manual on Uniform Traffic Control Devices for Streets and Highways.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Drawings showing layouts, actual letter sizes and styles, and Project-specific mounting details.
   b. Manufacturer’s literature showing letter sizes and styles, sign materials, and standard mounting details.
2. Samples: One full size for each type of nameplate, sign, and label specified.

B. Informational Submittals: Manufacturer’s installation instructions.

PART 2 PRODUCTS

2.01 DOOR NAMEPLATES

A. Material: Plastic with square corners.

B. Thickness: 1/8 inch.

C. Height: 2 inches.

D. Finish: Nondirectional matte.

E. Background: Black.

F. Letters: Raised.

1. Size: 1-inch high.
2. Color: White.
3. Style: Helvetica Regular upper case.
4. Message Text: As shown on Door and Hardware Schedule.
5. Braille Text: Domed or rounded as required by ADA regulations, with 3/8-inch minimum clearance on all sides.

G. Manufacturers and Products:

1. Best Sign Systems, Montrose, CO; Graphic Blast.
2. Andco Industries Corp., Greensboro, NC; 1400 series.

2.02 SIGN TYPES

A. Plastic Sign (Type A):

1. Exterior: Laminated plastic subsurface image type, 3/16 inch thick with high-gloss finish.
2. Interior: Plastic, 1/8-inch thick with nondirectional matte finish and raised letters.
3. Rounded corners.

B. Fiberglass Sign (Type C):

1. Material: Three-ply laminated fiberglass, minimum 1/8-inch thick, with contrasting color core message layer between two clear weather-resistant surface layers.
2. Manufacturers:
   a. Best Sign Systems.
   b. Brady Signmark.

C. Hazardous Material Sign (Type H):

1. Conform to NFPA 704 and NFPA HAZ-01.
2. Material: Fiberglass 1/8-inch thick.
3. Background, Letters, and Numbers: Die-cut vinyl with pressure sensitive adhesive.
4. Manufacturers:
   a. Brady Signmark.
   b. Emed Co., Inc.

2.03 IDENTIFICATION LABELS

A. Pipe Labels:

1. Snap-on, reversible type with lettering and directional arrows, sized for outside diameter of pipe and insulation.
2. Provided with ties or straps for pipes of 6 inches and over diameter.
3. Designed to firmly grip pipe so labels remain fixed in vertical pipe runs.
4. Material: Heavy-duty vinyl or polyester, suitable for exterior use, long lasting, and resistance to moisture, grease, and oils.
5. Letters and Arrows: Black on OSHA safety yellow background.
6. Color Field and Letter Height: Meet ASME A13.1.
7. Message: Piping system name as indicated on Piping Schedule.
8. Manufacturers and Products:
   a. Brady Signmark; B-915 BradySnap-On and Strap-On Pipe Markers.
   b. Seton Identification Products; Ultra-mark Pipe Markers.

B. Equipment Labels:

1. Applies to equipment with assigned tag numbers, where specified.
2. Letters: Black bold face, 3/4-inch minimum high.
3. Background: OSHA safety yellow.
4. Materials: Aluminum or stainless steel with a baked-on finish suitable for use on wet, oily, exposed, abrasive, and corrosive areas.
5. Furnish 1-inch margin with holes at each end of label, for mounting. On fiberglass labels, furnish grommets at each hole.
6. Size:
   a. 2 inches minimum and 3 inches maximum high, by 14 inches minimum and 18 inches maximum long.
   b. Furnish same size base dimensions for all labels.
7. Message: Equipment names and tag numbers as used in sections where equipment is specified.
8. Manufacturers:
   a. Brady Signmark.
   b. Seton Identification Products.

2.04 ANCILLARY MATERIALS

A. Fasteners: Stainless steel screws or bolts of appropriate sizes.

B. Wood Posts: Preservative treated 4 by 4 wood as specified in Section 06 10 00, Rough Carpentry.

C. Pipe Posts: 2-1/2-inch galvanized steel pipe meeting ASTM A53/A53M, Type S, Grade B.

D. Chain: Type 304 stainless steel, No. 16 single jack chain or No. 2 double loop coil chain.

E. Manufacturer's standard brackets for wall mounting of two-sided exit signs.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

A. In accordance with manufacturer's recommendations.

B. Mount securely, plumb, and level.

3.02 DOOR NAMEPLATES AND PICTORIAL SYMBOLS

A. Attach to doors with self-sticking permanent adhesive. See Door and Hardware Schedule for locations and messages.

B. Mount with bottom of nameplate at 5 feet 6 inches above floor.

3.03 SIGNS

A. General:

1. Fasten to walls or posts, or hang as scheduled.
2. Anchor in place for easy removal and reinstallation with ordinary hand tools.

B. Information and Safety Signs: Install facing traffic. Locate for high visibility with minimum restriction of working area around walkways and equipment.

C. Hazardous Material Sign:

1. Install where required by NFPA No. 704.
2. Install at entrances to spaces where hazardous materials are stored, dispensed, used, or handled, and on sides of stationary tanks.

3. Specific Materials:

Sign Schedule—Hazardous Material Signs								
Mark	**Material**	**Health Hazard (Blue)**	**Flammability Hazard (Red)**	**Instability Hazard (Yellow)**	**Special Hazard (White)**	**Location**	**Mounting Method**	**Height to Top**
H-1	Alum	2	0	0		See Schedule	As Scheduled	5'-6"

3.04 IDENTIFICATION LABELS

A. Pipe Labels:

1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
2. At intervals along piping not greater than 18 feet on center with at least one label applied to each exposed horizontal and vertical run of pipe.
3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
4. Supplementary Labels: Provide to Owner those listed on Piping Schedule that do not receive arrows.
5. Apply to pipe after painting in vicinity is complete, or as approved by Engineer.
6. Install in accordance with manufacturer's instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

3.05 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this specification.

1. Sign Schedule: Tabulation of characteristics and mounting information for warning, informational signs on Project. Provide items as scheduled. Meet requirements of Occupational Safety and Health Act (OSHA).

END OF SECTION

Sign Schedule

Sign									Lettering					Other Requirements
			Size			Mounting								
Number[1]	Sign Type[2]	Detail Reference[3]	Width	Height	Color	Location	Method	Height to Top	Height	Style	Color	Message	Faces	
S-1	C	1014-002	20"	14"	Yellow	Hanging	Chain	5'-6"	1" min.	Helvetica	Black	CAUTION Equipment Starts Automatically	4	Locate as directed by Engineer.
S-6	C	1014-001	20"	14"	White	Wall	Bolts	3'-6"	1" min.	Helvetica	Black	DANGER Nonpotable Water Not for Drinking	1	Provide at interior hose valves
S-7	B	1014-001	20"	14"	White	Pipe Post	Bolts	3'-6"	1" min.	Helvetica	Black	DANGER Nonpotable Water Not for Drinking	1	Provide at exterior hose valves
S-8	H-1	1014-006	10"	10"	White	Tank	By Tank Manuf.	5'-6"	1" min.	Helvetica	Black	Alum See Hazardous Material Sign Schedule.	2	Provide on two sides of tank visible by operator access to tank.
S-11[4]	C	1014-001	10"	7"	White	Door	Screws	5'-6"	1" min.	Helvetica	Black	DANGER CONFINED SPACE AUTHORIZED EMPLOYEES ONLY	1	
S-14	A	1014-008	20"	14"	White	Door	Screws	5'-6"	1" min.	Helvetica	Black	NOTICE Authorized Personnel Only	2	Electrical Room doors.
S-23	C	1014-003	20"	14"	Orange	Wall	Bolts	5'-6"	1" min.	Helvetica	Black	WARNING Corrosive Materials Wear Required Protection	1	Chemical Room door.

[1]Numbers refer to a particular sign type with a particular message.
[2]Letters refer to Sign Types specified in this section.
[3]Numbers refer to Design Details that show sign layout.
[4]Verify requirements for this sign with Regulations in state where Project is located.

SECTION 10 28 00
TOILET AND BATH ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Fire Protection Association (NFPA): 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

1.02 DESIGN REQUIREMENTS

A. Design grab bars, shower seats dressing room bench seats and attachments to resist minimum 250-pound (0.22-kN) concentrated load applied at any point in any direction.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's literature clearly indicating:
      1) Engineer's identification mark, size, and description of components.
      2) Base material with surface finish inside and out.
      3) Hardware and locks and attachment devices.
      4) Description of rough-in framing.
      5) Details of blocking and anchorage required.

B. Informational Submittals:

1. Distributor's List: List of local distributors for supplies required for accessories installed.
2. Cleaning instructions.

1.04 QUALITY ASSURANCE

A. Flame Resistant Fabric: Passes when tested in accordance with NFPA 701, Test 1 or Test 2.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and products specified in this section shall be products of:

1. Bobrick Washroom Equipment, Inc.
2. Bradley Corp.
3. Accessory Specialties, Inc.
4. Watrous, Inc.

2.02 TOILET AND BATH ACCESSORIES

A. Furnish accessory items listed where indicated by mark or note on Drawings.

Item	Mark	Bobrick	Bradley
Surf. Mounted Jumbo Roll Toilet Paper Dispenser	TPD-2	No. B-2890	No. 5424
Wall Mounted Liquid Soap Dispenser	SD-2	No. B-4112	No. 6542
Mirror, Size on Dwgs	MIR	No. B-290	No. 780
Surf. Mounted Paper Towel Dispenser and Receptacle	PTD/R-1	No. B-3949	No. 235-11
Mop and Broom Holder (24")	M&BH	No. B-223 x 24	No. 9953
Robe Hook	RH	No. B-6727	No. 9124
Grab Bars (straight) (36")	GB-1	No. B-6806-36	No. 812-001-36
Grab Bars (straight) (42")	GB-2	No. B-6806-42	No. 812-001-42
Grab Bars (shower, corner type)	GB-6	No. B-6861	No. 812-036 /037 Modified (15"x30")
Shower Curtain Rod	SCR	No. B-207	No. 9538
Flame Resistant and Antibacterial Shower Curtain with Hooks	SC	No. B-204-2/204-1	No. 9537/9536
Fold-Up Shower Seat (L-shaped)	SHS	No. B-518/517	No. 956/9561

B. Finish:

1. Satin stainless steel.
2. Manufacturer’s or brand name on face of units is not acceptable.

C. Anchors: Furnish anchors, fasteners, or other devices necessary for a complete, secure installation.

1. Fasteners: Tamper-proof screws or bolts.

D. Supplies: Furnish fill supplies, such as paper goods, soap, and napkins, as recommended by accessory manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Coordinate support framing and backing as necessary for proper installation of accessories.

B. Coordinate the Work with placement of internal wall reinforcement and reinforcement of toilet partitions to receive anchor attachments.

3.02 INSTALLATION

A. Mounting Heights and Locations: Locate where mark is shown on Drawings at height required by accessibility regulations**.**

B. Follow manufacturer’s instruction and recommendations.

C. Install and securely anchor accessories in their proper locations, plumb and level, and without distortion.

D. Remove protective masking and clean surfaces, leaving them free of soil and imperfections.

E. Fill units with necessary supplies within 10 days before Substantial Completion.

F. Deliver to Owner keys and devices required to fill and service units.

3.03 CLEANING

A. Clean and repair existing toilet accessories which remain or are to be reinstalled.

END OF SECTION

SECTION 10 44 00
FIRE PROTECTION AND SAFETY EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual (FM).
2. Mine Safety and Health Administration (MSHA).
3. National Fire Protection Association (NFPA):
   a. 10, Standard for Portable Fire Extinguishers.
   b. 30, Flammable and Combustible Liquids Code.
4. National Institute for Occupational Safety and Health (NIOSH).
5. Occupational Safety and Health Administration (OSHA).
6. Underwriters Laboratories Inc. (UL): Fire Protection Equipment Directory.

1.02 PERFORMANCE REQUIREMENTS

A. Conform to NFPA 10.

B. Provide extinguishers classified and labeled by Underwriters Laboratories Inc. for purpose specified and indicated.

C. Provide fire rated fire extinguisher cabinets classified and labeled by Underwriters Laboratories Inc. for purpose specified and indicated.

D. Provide key boxes as required by the applicable code or by the fire marshal or code official having jurisdiction.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Fire Extinguishers: Manufacturer’s product data for each item, including sizes, ratings, UL listings, or other certifications, and mounting information.
   b. Extinguisher Cabinets and Key Boxes: Indicate type of cabinet, cabinet physical dimensions, rough-in measurements for recessed and semi-recessed cabinets, wall bracket mounted measurements, location, fire ratings, mounting methods and anchorage details.
   c. Product Data: Extinguisher operational features, color and finish, and anchorage details.

B. Informational Submittals:

1. Manufacturer's Installation Instructions:
   a. Special criteria and wall opening coordination requirements.
   b. Manufacturer's installation details for fire-rated cabinets.
   c. Cabinet location plan.
2. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
3. Operation and Maintenance Data: Submit test, refill or recharge schedules and recertification requirements.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Section 01 61 00, Common Product Requirements: Environmental conditions affecting products onsite.

B. Do not install extinguishers when ambient temperatures are capable of freezing extinguisher ingredients.

PART 2 PRODUCTS

2.01 PORTABLE FIRE EXTINGUISHERS

A. Manufacturers:

1. JL Industries.
2. Larsen's Manufacturing Co.
3. Nystrom Products Co.
4. Potter Roemer.

B. General:

1. Conform to NFPA 10 for fire extinguishers.
2. Furnish fire extinguishers and cabinets from one manufacturer.
3. UL listed, charged and ready for service.

C. Multipurpose Hand Extinguisher (F. Ext-1):

1. Tri-class dry chemical extinguishing agent.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Agent propelled through hose or opening at top of unit.
5. For use on A, B, and C class fires.
6. Minimum UL Rating: 4A-60B:C, 10-pound capacity.

D. Clean Agent Hand Extinguisher (F. Ext-5):

1. Clean agent with nonozone depleting potential extinguishant.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Colorless, odorless, electrically non-conductive clean agent which discharges as a liquid and flashes to a gas.
5. Environmentally friendly, with zero ozone depletion potential, containing no chlorofluorocarbons, hydrochlorofluorocarbons, or halon.
6. For use on Class A, B, or C fires.
7. Minimum UL Rating: 2A-10B:C, 13-pound capacity.

2.02 FIRE EXTINGUISHER CABINETS

A. Manufacturers:

1. J. L Industries.
2. Larsen's Manufacturing Co.
3. Modern Metal Products.

B. Extinguisher Cabinet Type:

1. Semi-recessed.
2. Sized to accommodate accessories.

C. Metal: Formed sheet steel**,** primed 0.036 inch thick base metal.

D. Door: 0.016-inch thick, reinforced for flatness and rigidity; latch access.

E. Door Glazing: Glass, clear, 1/8-inch tempered.

F. Cabinet Mounting Hardware: Appropriate to cabinet and wall type.

G. Form cabinet enclosure with right angle inside corners and seams. Form perimeter trim and door stiles.

H. Predrill for anchors.

I. Hinge doors for 180-degree opening with two butt hinge. Furnish roller type catch.

J. Weld, fill, and grind components smooth.

K. Glaze doors with resilient channel gasket glazing.

L. Finishing Cabinet Exterior Trim and Door: Anodized to as selected**.**

M. Finishing Cabinet Interior: enamel.

N. Key Boxes: Select size and options according to authority having jurisdiction requirements. Other companies do make similar products. However, any system adopted by a Fire Department must be compatible from one installation to another. Only one master key will be carried on fire apparatus. This key must operate all lock boxes in the City. To maintain master key security, all companies in this business carefully guard master key codes. They will not release this information to any other manufacturer or supplier. These security concerns require that one supplier be selected for all installations in the City. Mounting height is also important and 6 feet 0 inch is recommended by Knox. However, AHJ should be consulted.

2.03 KEY BOXES

A. Manufacturers and Products:

1. Knox Company, Phoenix, AZ.
2. Kidde Fire Safety; SupraSafe, Mebane, NC.

2.04 ACCESSORIES

A. Extinguisher Brackets: For hand extinguishers not located in cabinets, furnish heavy-duty brackets with clip-together strap for wall mounting formed steel, enamel finish.

B. Graphic Identification: Provide graphic identification marking for each fire extinguisher type. OSHA approved pictorial markings to indicate the extinguisher uses and nonuses on a single label.

C. Fasteners: Furnish necessary screws, bolts, brackets, and other fastenings of suitable type and size to secure items of fire and safety equipment in position.

1. Metal expansion shields for machine screws at concrete and masonry.
2. Interior: Rust-resistant.
3. Exterior: Stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify cabinets are correctly sized for fire extinguisher type.

B. Verify rough openings for cabinet are correctly sized and located.

3.02 INSTALLATION

A. Install where indicated or directed and in accordance with manufacturer's recommendations.

B. Install cabinets plumb and level in wall openings, maximum 48 inches from finished floor to top of extinguisher handle.

C. Secure cabinets and brackets rigidly to structure.

D. Provide adequate backing for mounting surfaces.

E. Place extinguishers in cabinets or on wall brackets as shown on Drawings.

F. Position cabinet signage as required by authorities having jurisdiction.

G. Safety Chart: For each breathing apparatus, provide wall chart containing instructions for use and recommendations for safe handling of chlorine containers, emergency procedures, and applicable principles of first-aid.

3.03 PORTABLE FIRE EXTINGUISHERS AND CABINETS

A. Provide at locations shown or as directed by Engineer.

B. Mount hangers securely in position, following manufacturer's recommendations.

C. Top of Extinguisher: No more than 54 inches above floor.

D. Install wall brackets, maximum 48 inches from finished floor to top of extinguisher handle.

E. Fire-Rated Cabinets: Install in accordance with cabinet manufacturer's requirements. Maintain integrity of wall fire-rating.

3.04 WELDING SCREENS

A. Assemble following manufacturer's instructions and locate where shown on Drawings or as directed by Engineer.

END OF SECTION

SECTION 10 51 00
LOCKERS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.
2. Manufacturer's literature describing products proposed for use.
3. Color charts or samples illustrating colors available.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements. Submit with Action Submittal for the same item.
2. Installation instructions.

PART 2 PRODUCTS

2.01 LOCKERS

A. Type: Standard, single-tier single-door type made of cold-rolled sheet metal.

1. Locker sides, backs, tops, bottoms, and shelves; minimum 24-gauge steel.
2. Doors and frames; minimum 16-gauge steel.

B. Size: 15 inches by 18 inches by 72 inches.

C. Top: 20-gauge sloping top.

D. Bottom: 6-inch legs with closed base.

E. Doors: Standard, with louvers top and bottom.

F. Hinges and Door Strikes: Manufacturer's standard continuous type.

G. Locks Padlock attachment; furnish combination padlock and combination for each locker.

H. Shelves: One hat shelf with rolled front.

I. Coat Hooks: Three single-prong wall hooks and one double-prong ceiling hook in each compartment.

J. Number Plates: Noncorrosive with black numerals, numbered consecutively beginning with one in each room.

K. Finish: Baked-on enamel, over bonding and rust-resisting phosphate undercoat.

L. Color: To be selected from manufacturer's standard colors.

M. Anchor Bolts: Minimum 1/2-inch diameter (unless a larger minimum size is shown on Drawings) Type 316 stainless steel; total number and final size as required by equipment manufacturer and by Contractor's anchorage and bracing design per Section 01 88 15, Anchorage and Bracing. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications.

N. Manufacturers:

1. ASI Storage Solutions, Inc.
2. Lyon Workspace Products.
3. Penco Products, Inc.
4. Republic Storage Systems Company.
5. DeBourgh Mfg. Co.

2.02 SHOWER BENCH

A. Tops:

1. High-density polyethylene (HDPE) formed under pressure into single component section, with homogenous color throughout.
2. 9-1/2 inches wide by minimum 1-3/8 inches thick by lengths shown on Drawings.
3. Manufacturer's standard plastic sealer finish.

B. Pedestals:

1. Aluminum.
2. Heavy-duty tubes welded to top and bottom flanges.
3. 16 inches high, minimum.
4. Floor anchored. Anchor bolts minimum 1/2-inch diameter (unless a larger minimum size is shown on the Drawings) Type 316 stainless steel; total number and final size as required by equipment manufacturer and by Contractor's anchorage and bracing design per Section 01 88 15, Anchorage and Bracing. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications.

5. Spacing as recommended by manufacturer, but not to exceed 3 feet on center.
6. Finish and Color: Manufacturer's standard.

C. Manufacturers:

1. Comtec Industries.
2. Santana Plastic Products.

PART 3 EXECUTION

3.01 LOCKER INSTALLATION

A. Securely attach to wall, base, and to each other as recommended by manufacturer. Accurately place anchor bolts using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

B. Align and level lockers with shims where necessary to compensate for irregularities in the base.

C. Install trim, adjust doors and latches for proper operation, and leave lockers level, plumb, neat, rigid, and free from soil and imperfections.

3.02 SHOWER BENCH INSTALLATION

A. Attach pedestals to top with fasteners supplied by manufacturer and secure to floor with anchors recommended by manufacturer. Accurately place anchor bolts using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

END OF SECTION

SECTION 10 73 00
PROTECTIVE COVERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Project Facility Name: 40 – UV Facility Canopy.

1.02 RELATED SECTIONS

A. Section 01 61 00, Common Product Requirements.

B. Section 01 88 15, Anchorage and Bracing.

C. Section 03 30 00, Cast-In-Place Concrete.

D. Section 03 62 00, Grouting.

E. Section 05 50 00, Metal Fabrications.

1.03 REFERENCES

A. American Architectural Manufacturers Association (AAMA):

1. AAMA 605, Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions and Panels.

1.04 DESIGN REQUIREMENTS

A. Columns, Beams, Gutter Beams, Deck, and Trim: Aluminum extrusions.

B. Structural Framing: Interlocking deck sections roll locked and secured by screws. Mechanically fastened bents using internally concealed bolted connections.

C. Canopy: Self-draining from deck through bents to discharge point at belowground level stormwater piping or as otherwise shown.

D. Covers shall be all extruded aluminum system complete with internal drainage in flat canopy configurations with roll lock roof deck components as indicated on the drawings. Roll form, wedge locked or crimped deck is not permitted.

E. Building Code: International Building Code, 2012.

F. Design Criteria:

1. Comply with the requirements in Section 01 61 00, Common Product Requirements.
2. Comply with Building Code for site location.
3. Collateral Loads: Additional loads imposed by other materials or systems identified in Contract Documents.
4. Maximum design deflections shall be:
   a. Vertical deflection under total load: 1/180 of the span.
   b. Vertical deflection under live load: 1/240 of the span.
   c. Horizontal deflection of the frame: 1/120 of the span.

G. Structural Design: Prepare complete structural design calculations for canopy members, including anchorage to the foundation. All protective covers, including columns, deck, and attachments to the concrete walkway slabs/foundations, shall be designed and detailed by a qualified professional engineer registered in the State of Tennessee.

1.05 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer's catalog data, detail sheets, and specifications.
2. Shop Drawings: Scaled layout and erection drawings showing roof framing, deck panels, cross sections, trim details, and anchorage, clearly indicating proper assembly signed and sealed by a licensed engineer registered in the State of Tennessee.
3. Loading diagrams.
4. Samples: Color selection samples consisting of actual coating material on aluminum extrusion for use to confirm matching of up to two manufacturer’s standard colors.

B. Informational Submittals:

1. Complete design calculations for member stresses, deflections, connections and anchorage.
2. Qualifications: Letter certifying manufacturer's required qualifications.
3. Structural Design Calculations signed and sealed by a licensed engineer registered in the State of Tennessee.
4. Manufacturer's Installation Instructions.

1.06 QUALITY ASSURANCE

A. Overall Standard: Structural engineering shop drawings and design calculations stamped by a structural engineer registered to practice in the State of Tennessee.

B. Manufacturer Qualifications: Minimum 5 years' experience in producing covers/canopies with welded bents and of the type specified.

C. Installer Qualifications: Minimum 2 years' experience in erecting covers/canopies of the type specified.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Conform to Section 01 61 00, Common Product Requirements.

B. Follow manufacturer's instructions.

PART 3 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers:

1. Perfection Architectural Systems, Inc., 2310 Mercator Drive, Orlando, FL 32807; ASD. Tel: (800) 238-7207, Fax: (407) 671-8252.
2. Peachtree Protective Covers, 1477 Rosedale Drive, Hiram, GA 30141; Tel: (800) 341-3325.
3. Mitchell Metals, 1761 McCoba Drive SE, Smyrna, GA 30080; Tel: (770) 766-5521, Fax: (770) 431-7305.

B. Provide all protective covers from a single manufacturer.

2.02 MATERIALS

A. Metals: In accordance with Section 05 50 00, Metal Fabrications, except Aluminum Extrusions shall be 6063 alloy, T-6 temper.

B. Grout: In accordance with Type II of Section 03 62 00, Nonshrink Grouting.

C. Foam Block-Outs: Rigid foam blocks sized as required for column embedment depth and shape.

2.03 COMPONENTS

A. Columns:

1. Radius-cornered aluminum tubular extrusion of size shown on Drawings.
2. Radius-cornered aluminum tubular extrusion as required by structural engineering design.
3. Grout Key: Provide two 1-1/2-inch diameter holes in column base, one each in opposite sides.
4. Provide clear acrylic protection coat on surfaces in contact with grout.

B. Beams: Open top aluminum tubular extrusions.

1. Size: As required by structural engineering design.

C. Deck: Rigid-Roll-Lock extruded aluminum, self-flashing, interlocking sections.

1. Size: As required by structural engineering design.
2. Provide welded endplate water dams where sections terminate at other than drainage channels. Sealed or caulked in place dams are not acceptable.

D. Fascia: As required to complete the installation resulting in a neat finished appearance.

E. Flashing: Aluminum sheet, thickness as recommended by manufacturer for specific condition.

2.04 ACCESSORIES

A. Fasteners:

1. Deck Screws: No. 14 by 1 inch, self-tapping, Type 18-8 stainless steel with neoprene washers.
2. Trim Screws: No. 10 by 1/2 inch, self-tapping, Type 18-8 stainless steel.
3. Trim Rivets: Aluminum, size recommended by manufacturer for specific condition.
4. Other Fasteners: Type 18-8 stainless steel, type recommended by manufacturer for specific condition.

B. Anchors: In accordance with Section 05 50 00, Metal Fabrications, minimum 1/2-inch diameter.

C. Underground Stormwater Pipe: Aluminum pipe mounted to column drain outlet for connection to underground stormwater piping.

2.05 FABRICATION

A. Shop Assembly: Fabricate cross beams and columns for field assembled bolted connections.

2.06 FINISHES

A. Fluoropolymer Coating: 70 percent PVDF resin based fluoropolymer, AA-C-12C-42R-1, color as selected by architect from manufacturers standard colors, nonmetallic, comply with AAMA 605.

1. Two coat application.
2. Maximum of two Manufacturer’s standard colors as required by Owner.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine footings in which bents will be set. Verify footing locations and elevations comply with Shop Drawings.

B. Coordinate with responsible trade to perform corrective work on unsatisfactory footings or surfaces.

C. Commencement of work by installer is acceptance of existing conditions.

3.02 ERECTION

A. Erect protective covers in accordance with manufacturer's installation instructions.

B. Set bents plumb, straight, and true to line, adequately braced to maintain position until grout has cured.

C. Keep aluminum surfaces from direct contact with ferrous metal or other incompatible materials by applying one coat of clear acrylic coating.

D. Field connections shall be bolted or fastened. Field welding will not be permitted.

3.03 CLEANING

A. Clean surfaces soiled by work as recommended by manufacturer.

B. Remove surplus materials and debris from the site.

3.04 PROTECTION

A. Protect finished aluminum surfaces from damage due to subsequent construction operations.

END OF SECTION

SECTION 10 80 00
MISCELLANEOUS SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Writing board.
2. Tackboard.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
2. UL (UL): Building Materials Directory.

1.03 SUBMITTALS

A. Action Submittals:

1. Manufacturers' product data for proposed items. Clearly identify each item.
2. Manufacturers' color charts.

B. Informational Submittals:

1. Manufacturers' installation instructions.
2. Manufacturers' cleaning and service instructions for proposed items.

PART 2 PRODUCTS

2.01 WRITING BOARDS

A. Materials: Stretcher level sheet steel facing, 24-gauge minimum, bonderized and surfaced to accept watercolor and semipermanent writing inks with selective erasability, minimum 3/8-inch particleboard core, 0.015-inch aluminum backing sheet, extruded aluminum frame and tray.

B. Composition: Facing sheet and backing sheet bonded to opposite sides of core.

C. Finish and Color: White porcelain enamel semigloss writing surface finish impervious to cracking, checking, chipping, and peeling; bronze anodized finish on extruded aluminum frame and tray.

D. Size: As noted on Drawings.

E. Accessories: Twelve watercolor markers, six black and six assorted colors compatible with writing surface; cleaners, towels, magnetic strips, and instruction booklet.

F. Manufacturers and Products:

1. AARCO Products, Inc., Yaphank, NY; Series 10-120 and 10-008.
2. Claridge Products & Equipment, Inc., Harrison, AR; Series 4, Type A.
3. Lemco, Inc., West Jordan, UT; Type 3, No. 250.

2.02 TACKBOARDS

A. Materials: 1/4-inch vinyl-impregnated cork; 1/4-inch tempered hardboard backing; extruded aluminum frame without tray.

B. Composition: Cork face sheet, factory cemented to backing.

C. Finish and Color:

1. Ground natural cork with washable vinyl finish and integral color throughout.
2. Cork Surface Color and Texture: Natural; bronze anodized finish on extruded aluminum frame.

D. Size: 3 feet by 4 feet.

E. Accessories: Clip angle hangers at 24 inches on center top and bottom.

F. Manufacturers and Products:

1. AARCO Products, Inc., Yaphank, NY; Series 10-120 and 10-015.
2. Claridge Products & Equipment, Inc., Harrison, AR; Series 4, Type CO.
3. Lemco, Inc., West Jordan, UT; Type 3, No. 311.

PART 3 EXECUTION

3.01 INSTALLATION OF SPECIALTIES

A. Follow manufacturer's recommendations and printed instructions. Consult with Engineer in order that minor adjustments in locations can be decided if necessary.

1. Install materials plumb or level as applicable and attach securely to adjacent materials with suitable fasteners.
2. Prevent scratching or damaging adjacent materials during installation.

END OF SECTION

SECTION 12 20 00
WINDOW TREATMENTS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Details of installation indicating size, attachments, and clearances of operating hardware with other construction.
2. Samples: Metal slat samples in the full standard color spectrum available for color selection (Minimum 2-inch by 1-inch lengths).

B. Informational Submittals: Manufacturer's written instructions for the care, repair, and cleaning of all components provided in the Work. Include a detailed list of hardware parts identified by manufacturer's catalog numbers and diagrams of installation methods. Include color selection chart.

1.02 QUALITY ASSURANCE

A. Installer Qualifications:

1. Experienced and regularly engaged in the installation of window blinds.
2. Use proper facilities and methods for production of the Work.
3. Acceptable to the Engineer.

B. Mockups: Blind hardware systems together with proposed blades and incorporate all details of operation and appearance to be anticipated in the complete installations for windows as indicated. Install mockups where directed by Engineer and obtain approval before proceeding. Approved mockup will be used as control Sample for workmanship and fabrication.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Do not deliver blinds until ready for installation.
2. Handle in accordance with manufacturer's instructions.

B. Storage and Protection: Store blinds and accessories in unopened packages in manner to prevent damage from environmental and construction operations.

1.04 SPECIAL GUARANTEE

A. Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 3 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Horizontal Blinds: Aluminum horizontal slats 1 inch wide supported by braided ladders and hardware enclosed in a metal head.

1. Slat Supports:
   a. Braided ladders of polyester yarn, the vertical component not less than 0.045-inch diameter nor greater than 0.068-inch diameter for maximum strength and flexibility with minimum stretch.
   b. Support slats parallel and straight to assure proper tilt control and adequate overlap of slats.
   c. 15 rungs per foot of ladder equally spaced at 0.788-inch intervals.
   d. Distance between ladders, not exceeding 24 inches.
   e. The horizontal component of rungs consist of not less than two cables interbraided with the vertical components.
2. Slats: Type 6011 spring tempered aluminum alloyed for maximum strength, flexibility, and resistance to internal and external corrosion; 0.984-inch wide and 0.008-inch thick before painting; paint 1.5 mils thick.
3. Headrail: Channel-shaped steel section, 0.025-inch thick complete with tilting mechanism operated by turning wand.
4. Bottom Rail: Steel 0.031-inch thick, finished with a plastic type coating cured at high temperature and formed after coating.
5. Lift Cord: Adequate diameter braided of high strength synthetic fibers to provide minimum stretch and maximum strength and flexibility.
6. Finish: Standard factory finish with slat, headrail and bottom rail color to be selected from manufacturer's full array of available colors by the Engineer, Architect or Owner.
7. Manufacturers and Products:
   a. Levolor Lorentzen, Inc., Lyndhurst, NJ 07071; Riviera Blind.
   b. Marathon Carey-McFall, Montoursville, PA 17754; Bali Blinds
   c. Hunter Douglas, Inc., Totawa, NJ 07512; Flexalum Decor 1-inch Blind.

B. Quantity: See window schedule on Drawings for locations of horizontal blinds.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements of openings to receive blinds, and provide systems in coordination with work of other trades. Delay installation until all other finish Work in spaces is complete.

3.02 BLIND INSTALLATION

A. Install the hardware to manufacturer's recommendations as approved for conditions of the installation. Install in accurate locations, make plumb, true to line, complete with accessories required for satisfactory operations, attach to building construction using approved type of fasteners so as to be rigid and secure, taking care to prevent cracking, marring, or other damage to adjacent finished surfaces.

3.03 ADJUSTING

A. After installation, test and adjust each unit.

3.04 CLEANING

A. Leave installation in a clean and dust-free condition.

END OF SECTION

SECTION 12 35 53
LABORATORY CASEWORK

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A135.4, Basic Hardboard.
   b. A208.1, Particleboard, Mat-Formed Wood.
   c. Z358.1, Emergency Eyewash and Shower Equipment.
2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE): 110, Method of Testing Performance of Laboratory Fume Hoods.
3. Americans with Disabilities Act (ADA).
4. APA–The Engineered Wood Association (APA): Grades and Specifications.
5. Architectural Woodwork Institute, Architectural Woodwork Manufacturers Association of Canada, Woodwork Institute (AWI, AWMAC, WI): Architectural Woodwork Standards.
6. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A507, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
   c. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   d. C1048, Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass.
   e. D1193, Standard Test for Reagent Water.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
7. National Electrical Manufacturer's Association (NEMA):
   a. LD 3, High Pressure Decorative Laminates (HPDL).
   b. WD 1, General Color Requirements for Wiring Devices.
8. National Institute of Standards and Technology (NIST), Product Standard Section: PS 1, Structural Plywood.
9. National Fire Codes–National Fire Protection Association (NFPA):
   a. 30, Flammable and Combustible Liquids.
   b. 45, Fire Protection for Laboratories Using Chemicals.
10. Occupational Safety and Health Administration (OSHA): General Industry Standards, Section 1910.106.

11. Scientific Equipment and Furniture Association (SEFA):
    a. SEFA 1, Recommended Practices For Laboratory Fume Hoods.
    b. SEFA 2, Recommended Practices For Installations.
    c. SEFA 8, Recommended Practices For Laboratory Grade Casework.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Completely describe and illustrate design features, materials, fabrication, and casework layout including rough-in details for plumbing, electrical, and ventilation connections.
    a. Key units to Contract Document designations.
    b. Provide details and dimensions not controlled by job conditions.
    c. Show required field measurements beyond manufacturer's control.
    d. Establish and maintain applicable rough-in and field dimensions.
    e. Descriptive literature and manufacturer's specifications of casework, hardware, service fixtures, and specialty items.
    f. Brochures, catalogs, installation instructions, and operations and maintenance manuals.
    g. Clearly mark with Contract Document designation each proposed item in manufacturer's literature.
    h. Coordinate Shop Drawings with other trades.
    i. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.
2. Samples:
    a. Finished color Samples of each finish proposed by casework manufacturer.
    b. Sample unit, complete with hardware including locks, accessories, and top for Owner's inspection and 1 month's use. Unit, except top, may be used on Project.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements. Submit with Action Submittal for the same item.
2. Fume hood performance test results.
3. Qualifications of manufacturer and installation lead person.

1.03 QUALITY ASSURANCE

A. Standards:

1. Casework: Conform to AWI, AWMAC, and WI Architectural Woodwork Standards, Section 10, Premium grade, including laboratory features.
2. Fume Hoods: Conform with testing method of ASHRAE 110 and resulting instantaneous and average performance rating of 8 AM 0.1 (controls or limits loss of containment to less than 0.1 part per million "as manufactured" at release rate of 8 liters of sulfur hexafluoride per minute over the testing period) with face velocity of 100 fpm.

B. Casework Manufacturer Qualifications:

1. Reputation for doing satisfactory work on time.
2. Successful completion of comparable work.
3. Specialization in design and manufacture of plastic laminate casework or furnishings for scientific laboratories.
4. Operation of adequate size factory devoted to manufacture of plastic laminate laboratory casework or furnishings.
5. Exclusion of brokers and unauthorized representatives.
6. Minimum 5 years' experience in manufacture of quality and type of laboratory casework and furnishings specified.

C. Installation Services**:** Install under direct supervision of factory-trained representative of casework manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver materials to Project Site until excessive moisture is out of building for at least 10 days.

B. Store casework inside in dry and well-ventilated areas, and do not subject to extreme changes in temperature or humidity.

C. Coordinate delivery and installation with Engineer. Owner may wish to inspect items in Contractor's presence to verify condition.

PART 2 PRODUCTS

2.01 CASEWORK MANUFACTURERS

A. Plastic laminate faced casework of the following manufacturers, meeting these Specifications, may be used on this Project:

1. LSI Corp., Minneapolis, MN.
2. Nolen Products, Knoxville, TN.

3. TMI Systems, Dickinson, ND.
4. Westmark Products, Tacoma, WA.
5. Institutional Casework, Inc., Paris, TN.
6. Kewaunee Scientific Corporation, Statesville, NC.
7. Laboratory Design and Supply, Buford, GA.

2.02 CASEWORK MATERIALS

A. Plywood: APA exterior type conforming to NIST, Product Standard Section, PS 1.

1. Thickness: Minimum 3/4 inch.
2. Grade: No knots or voids present on surfaces. Use marine grade for cabinet bases.

B. Chemical-Resistant Plastic Laminate:

1. High-pressure plastic laminate for cabinet surfaces, excluding countertops.
2. Thickness: 0.034 inch plus or minus 0.005 inch.
3. NEMA LD 3, Grade HGP 30 with Grade CLS 20 backing.
4. Chemical Resistance for 16-Hour Contact Period:
   a. No effect for dilute acids, solvents, bases, indicators, biological stains, and general reagents.
   b. Only slight change of gloss or color for 48 percent hydrofluoric acid, chromic acid, 85 percent phenol, and 78 percent calcium thiocyanate.
   c. Only slight damage for 70 percent nitric acid and 96 percent sulfuric acid.
5. Color: Selected by Owner from manufacturer’s standard colors.
6. Manufacturer and Product: Wilsonart; Chemsurf.

C. Edge Banding:

1. Minimum 3-mm-thick polyvinyl chloride.
2. Color: Selected by OWNER from manufacturer’s standard colors.

D. Seismic Edges:

1. Shelves:
   a. Material: PVC formed with edge banding.
   b. Thickness: 3 mm.
   c. Height: 1 inch(es) above top of each shelf.
2. Reagent Shelves:
   a. Material: Same as reagent shelf.
   b. Thickness: Minimum 1/2 inch.
   c. Height: 1 inch(es) above top of each shelf.

E. Hardware:

1. Cabinet Locks (CLK):
   a. Pin tumbler type with dull chrome finish (626).
   b. Key locks alike.
   c. Manufacturers and Products:
      1) Sargent & Co.; Model No. 1655 MKD.
      2) Schlage; Model No. CL100PB.
      3) Olympus Lock, Inc.; 700.
2. Hinges: Concealed type, minimum 120-degree opening with spring closer.
3. Pulls: Manufacturer's standard semiflush type of molded ABS plastic in color selected by OWNER from manufacturer's standard colors.
4. Shelf Fasteners: Metal or plastic design providing rigid and true shelf alignment.
   a. Metal: Dull chrome finish.
   b. Plastic: Match cabinet interior color.
5. Drawer Slides:
   a. Metal designed to mate with drawer slides in cabinets.
   b. Provide smooth sliding action.
   c. Load Support on Extended Drawer: 200 pounds in file drawers, 75 pounds in drawers 6 inches and less in depth, and 100 pounds in other drawers.

F. Accessories: Manufacturer's standard catches, grommets, and other accessories and trim required to complete installation in secure and rigid manner. Finish to match other exposed hardware.

G. Transparent Doors: Clear tempered float glass, conforming to ASTM C1048, Kind FT, Condition A, Type I, Class 1, glazing quality, 1/4-inch (6 mm) minimum thickness.

H. Adhesives: Manufacturer's standard water-resistant adhesives.

I. Countertops:

1. Epoxy Resin:
   a. Molded, modified, solid epoxy resin.
   b. Formulated to produce smooth, nonabsorbent, chemical-, heat-, and shock-resistant surface.
   c. Homogeneous in color and texture.
   d. Thickness: Minimum 1 inch.
   e. Drip groove under front edge.
   f. Integral two-piece glued backsplash for full length of adjoining walls.

g. Color: Black or dark gray.
h. Manufacturers and Products:
1) Durcon; Durcon Resin.
2) Prime Industries, Inc.; Prime-Resin.

2. Stainless Steel: ASTM A666 or ASTM A167.
a. Type: 316 stainless steel sheets.
b. Thickness: U.S. Standard 18 gauge.
c. Formed over 3/4-inch thick hardwood, plywood, or composition board core.
d. Raised front edge and sides.
e. Integral splash and sinks where shown on Drawings.
f. Joints welded, ground smooth, and polished.
g. Finish: No. 6, dull satin.

J. Backsplashes, Backsplash Returns, Splash Curbs (SCB), Reagent Shelves, and Reagent Shelf Supports: Same material as adjacent countertop.

K. Drain Troughs: Epoxy resin to match adjacent countertop.

L. Drain Racks (DRK): Polypropylene pegs on epoxy resin countertop material in sizes shown on Drawings and Drain Rack Detail.

2.03 FUME HOOD FHD-1

A. Description:

1. 6-foot automatic bypass air type fume hood.
2. Size: 72 inches long by 37.7 inches deep by 59 inches high exterior dimensions.
3. Placement: No part of foil or superstructure to extend more than 3-1/4 inches beyond edge of countertop into aisle space.
4. Fire- and chemical-resistant finish inside and out.
5. Construction: Flame-resistant molded fiberglass reinforced polyester resin interior and steel exterior.
6. Two remote service fixtures indexed and located where shown on Drawings.
7. One ground fault circuit interrupt (GFCI) electrical duplex receptacle(s) located where shown on Drawings.
8. Postless, pulldown, safety glass sash.
9. Matching U.S. Standard 18-gauge, ASTM A507, mild steel closure panels (CPL) to close openings to within 1 inch above installed fume hood.
10. Epoxy resin dish molded countertop surface to contain spills.
11. Cup Sinks: Locate where shown on Drawings with deck-mounted vacuum breaker cold water fixture with serrated nozzle end discharging into cup sink.

12. Acid storage: Base cabinets provided by same manufacturer as fume hood and designed to be integrated with fume hood model. Capable of supporting minimum of 800 pounds.
13. Operation Mode: Conventional automatic bypass with bypass air varying with sash height.
14. Fixed, nonadjustable baffle.
15. Removable front and side panels, and front access panels, for access to plumbing and electrical connections.
16. Face Velocity: Design for 100 fpm with sash full open (1,150 cfm at 0.41-inch water column external static pressure)from remotely located motor/blower.
17. Exhaust Duct Connection: 12.8-inch inside diameter.
18. Electronic sensor, digital face velocity monitor (FVM) with audible and visible alarm for low flow conditions, night setback, flush mounted on face rail as shown on Drawings.
19. 120 Volt, 20 Amp: Connect light, light switch, receptacles, and FVM in accordance with local codes.
20. Color: Selected by Owner from manufacturer's standard colors.

B. Manufacturer and Product: Labconco; Model No. 11061002.

2.04 LABORATORY EPOXY RESIN SINK LSK-1

A. Description:

1. Single Compartment: One-piece, molded epoxy resin with coved corners and corner outlet.
2. Size: 21-1/2 inches long by 15-1/2 inches wide by 11 inches deep interior dimensions.
3. Epoxy resin sink drain outlet complete with removable strainer, stopper, and 1-1/2-inch tailpiece.

B. Manufacturers and Products:

1. Durcon; Model No. D45.
2. Prime Industries; Model No. P-45.

2.05 EYE/BODY WASH EWH-1

A. Description:

1. Handheld, countertop-mounted unit.
2. Capable of flushing both eyes simultaneously.
3. 6-foot hose and 1/2-inch connectors.
4. White enamel epoxy coating applied by manufacturer's electrostatic powder coating process, except hose.

5. Deck mounting bracket and hose guide bracket.
6. Squeeze type, stay-open, lever handle valve.
7. Angle-mounted stainless steel head (not flat) for continuous use without hands.
8. Universal emergency sign.

B. Manufacturers and Products:

1. Speakman; Model No. SE-927.
2. Haws; Model No. 8904.
3. Guardian; Model No. G5022.
4. WaterSaver; Model No. EW1041.

2.06 LABORATORY SERVICE FIXTURES

A. General: Protect chrome plumbing service fixtures with white epoxy enamel coating applied by manufacturer's electrostatic powder coating process.

B. Deck-Mounted Gooseneck Faucet LP-1:

1. Rigid gooseneck, vacuum breaker, and removable serrated nozzle.
2. Faucet handle position(s) as shown on Drawings.
3. Index for cold water.
4. Manufacturers and Products:
   a. Chicago Faucets; Model No. 928-CP.
   b. WaterSaver Faucet Co.; Model No. L611VB.

2.07 FURNISHINGS AND EQUIPMENT

A. Refrigerator/Freezer, Laboratory, RFR.

B. Washer, Glassware, GWR.

2.08 CASEWORK FABRICATION

A. Construct casework of plywood, covered with laminated plastic sheets on both surfaces.

B. Furnish manufacturer's standard modular units conforming as closely as possible to dimensions and configurations shown on Drawings, or specially made casework units where standard sized units do not conform to dimensions and configurations shown on Drawings.

C. Construct casework with face screwed fasteners. Do not depend on mechanical fastening, gluing, or screwing of core edges for strength.

D. Excluding countertops, fabricate cabinet surfaces (fronts, backs, sides, tops, bottoms, shelves, doors, drawer fronts, bases, and fillers) with minimum 3/4-inch-thick plywood covered with chemical-resistant plastic laminate on both sides bonded by polyester resin at high pressure and temperature. Seal and protect cabinet and drawer surfaces from water intrusion.

E. Radius exposed corners at least 1/4 inch.

F. Protect edges from water intrusion including edges not exposed to view, e.g. resting on base, sitting on floor, standing behind cabinet. Install vinyl edges on exposed edges of cabinets, doors, and drawers. Locate joints in vinyl edges where least noticeable. Bond under pressure with waterproof hot melt glue and finish with smooth, radiused edges, and corners.

G. Cabinet Bases:

1. Design and construct separately from side and back panels to support cabinets rigidly in true alignment.
2. Material: Marine grade exterior plywood.
3. Height: 4 inches.
4. Install adjustable leveling feet at each corner and at intermediate points necessary for rigid support.

H. Countertops: Self-edged type.

I. Backsplashes and Splash Curbs: Field glued.

J. Cabinet Fronts: Flush design with no projecting edges.

K. Access Panels: Removable units opening to pipe space behind cases at knee spaces, balance tables, ends of islands and peninsulas, and elsewhere for access.

L. Sliding Glass Doors: Frameless type in wall-mounted or double-sided island or peninsula-mounted cases. Framed type for tall storage cabinets and base cabinets.

M. Cabinet Locks, CLK: Doors and drawers where shown on Drawings.

N. Color: Countertops, fronts, trim, and other exposed surfaces as selected by OWNER from manufacturer’s standard colors.

O. Seismic Edges: Accessible sides of open shelves including reagent, wall, and pass-through units located above countertop height and on adjustable shelves only of closed, sliding glass door units at any height.

P. Wood Drawers: Construct in accordance with AWI, AWMAC, WI Architectural Woodwork Standards Premium grade including laboratory features.

PART 3 EXECUTION

3.01 INSPECTION AND PREPARATION

A. Make field measurements of items or conditions affecting casework, equipment, and furnishings.

B. Examine grounds and supports of casework to assure adequate anchorage, free of foreign material, moisture, and unevenness that would prevent quality casework installation.

C. Verify that ventilation outlets, service connections, and supports are correct and in proper location.

D. Identify and correct defects before proceeding with installation.

3.02 INSTALLATION

A. Use proper type of anchoring devices for materials encountered. Accurately place anchor bolts using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

B. Install in accordance with manufacturer’s instructions.

C. Except where noted, install in new and ready-to-use condition.

D. Cut, fit, patch, and provide support where required for proper and complete installation.

E. Casework:

1. Secure casework in place in true alignment, level, and plumb. Secure casework units to cleats anchored to building structure or wall framing. Install wall-hung cabinets to firmly and rigidly support cabinet weight plus normally expected cabinet content weight.
2. Fasten together adjoining cabinets in an assembly joined at top and bottom of front and back with bolts placed inconspicuously inside cabinets.
3. Close exposed-to-view openings larger than joints with filler of same material and finish as adjacent casework. Secure filler to casework with concealed screws. Use minimum width and number of fillers consistent

with need. Except where shown on Drawings, do not use filler panels (FPL) exceeding 6-inch width.

4. Install cabinet front face 3 inches in front of cabinet base face to provide toe space.
5. Anchor shelf fasteners with screws when seismic edges used. Position shelves as directed by Owner.

F. Countertops:

1. Install standing height countertop's working surface 37 inches above finished floor. Install desk height countertop's working surface 31 inches above finished floor.
2. Install level to within 1/16 inch in 10 feet and in largest possible increments.
3. Where not supported by base cabinets or other furnishings, use brackets or other support on minimum 3-foot centers.
4. Make joints with manufacturer-provided cement containing same color and chemical-resistance characteristics as top material. Leave joints smooth and in same plane as top.

G. Laboratory Sinks and Service Fixtures:

1. Install in countertops and cases in manner recommended by manufacturer.
2. Take care to avoid scratches and other damage to cases and countertops.
3. Install ready for connection of services.

H. Furnishings:

1. Provide equipment with connection terminals for plumbing, electrical, ventilation, and refrigeration service connections where required.
2. Where items are supplied without line cords, furnish line cord and plug compatible with electrical service and available outlets.

3.03 FUME HOOD TESTING

A. Test installed fume hoods for flow visualization, both local and large-volume challenges, and face velocity in conformance with test methods of current ASHRAE 110 and resulting instantaneous and average performance rating of 4 AI 0.1 (controls or limits loss of containment to less than 0.1 part per million "as installed" at release rate of 4 liters of sulfur hexafluoride per minute over the testing period) with face velocity of 100 fpm.

B. Conduct testing after HVAC balancing as required by Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, has been completed.

C. Replace fume hood for failure to meet flow visualization challenges, to maintain average face velocity within 100 plus or minus 20 fpm, or to attain individual face velocity readings within plus or minus 10 fpm of the average.

3.04 ADJUSTING AND CLEANING

A. Adjust hardware and leave in smooth, easy condition. Remove protective maskings. Clean surfaces ready for use. Restore stained or discolored finishes or replace item.

B. Inspect, adjust, clean, and test service fixtures to assure intended operation.

END OF SECTION

SECTION 13 34 23
FABRICATED STRUCTURES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 90A, Energy Conservation in New Building Design.
   b. Fundamentals Handbook.
3. ASTM International (ASTM):
   a. C920, Standard Specification for Elastomeric Joint Sealants.
   b. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. National Institute of Standards and Technology-Product Standards Section (PS): 15, Custom Contact-Molded Reinforced Polyester Chemical-Resistant Process Equipment.
5. National Fire Protection Association (NFPA):
   a. 10, Portable Fire Extinguishers.
   b. 70, National Electrical Code.
   c. 90A, Standard for Installation of Air Conditioning and Ventilating Systems.
   d. 101, Life Safety Code.

1.02 SYSTEM DESCRIPTION

A. Building Name: Alum Building.

1. Alum Feed Building.
2. Size: As shown on details in Design Drawings.
3. Roof Slope: Manufacturer’s standard or as otherwise shown.
4. Include: Doors louvers, insulation, ventilation fan, unit heater, lights, pre-wired electrical conduit and wiring and roof accessories.

B. System: Design, furnish, and install complete FRP building package using manufacturer’s standard components.

C. Structure: Fabricated fiberglass environmental enclosure designed to be moved and installed as a single unit.

D. Design: Coordinate enclosure design with electrical equipment and chemical feed system to be enclosed.

E. Control indoor air quality and provide electrical illumination and power.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's Standard Details and Structural Calculations: Clearly mark those portions that apply to specific Project and those parts that do not apply.
   b. Manufacturer's Literature and Technical Data: Drawings and Specifications for proposed building system.
   c. Drawings prepared specifically for this Project:
      1) Materials and Details: Show materials, details of components (including doors and other accessories), finishes, fastenings, methods of joining, sealants, anchor bolt, shear angle, and baseplate details, including all sizes and dimensions, size and location of structural members and bracing, wall structural members, bracing, and openings.
2. Samples: Colors of metal siding and interiors available.

B. Informational Submittals:

1. Experience records of manufacturer and installer.
2. Approval of installer by manufacturer of structure components.
3. Certification that codes and referenced standards have been met.
4. Description and details of electrical continuity and grounding methods.
5. Test reports.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Designers: Engineers registered in state where building is to be erected.
2. Manufacturer:
   a. At least 5 years' experience in work of the type required in this section.
   b. Production capacity to provide work required for this Project without delay.
3. Erector/Installer:
   a. Not less than 5 years' experience in the erection of prefabricated structures similar to this Project.
   b. Approved by manufacturer of building components.

B. Regulatory Requirements: Design building system to meet requirements of:

1. International Building Code 2012 Edition.
2. International Mechanical Code 2012 Edition.
3. International Energy Conservation Code 2012 Edition.
4. International Fire Code 2012 Edition.
5. National Electrical Code, State of Tennessee.
6. State of Tennessee Amendments.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver building components in undamaged condition to Site only when ready for installation.

B. Protect products from damage and deterioration.

C. Handle products in accordance with manufacturers' instructions.

1.06 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a minimum period of 5 years and as stated below after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

B. Conditions: Roofing will remain weathertight for 20 years.

PART 2 PRODUCTS

2.01 BUILDING SYSTEM MANUFACTURERS

A. Products of the following, meeting these Specifications, may be used on this Project:

1. Tracom.
2. Kenco.

2.02 SYSTEM PERFORMANCE

A. Design Criteria shall comply with the requirements in Section 01 61 00, Common Product Requirements.

B. Structural Loading: Design structure in accordance with the Design Criteria listed on the General Structural Notes Drawing.

C. Outside Design Conditions:

1. Temperature: Shall be able to tolerate, without compromise to the structural integrity, temperatures between negative 10 and 105 degrees F.

2.03 COMPONENTS

A. Substructure: Cast-in-place concrete foundation and compacted base to be provided by the Contractor.

B. Doors: Enclosure should include a double door. Door leaf size: 36 inches by 84 inches.

C. Shell:

1. Provide weathertight structure that has straight, plumb walls with square corners.
2. Slope roof to drain, collect storm water, and conduct to Site storm drain.
3. Provide solid enclosure with no openings capable of allowing rodents or other small animals entry into the building.
4. Exterior finishes: Manufacturer’s Standard.

D. Interiors:

1. Walls: Vertical, smooth surface with minimum joints or seams, painted with scrubbable paint.
2. Provide structural reinforcement in walls at all locations where equipment is to be attached to the walls.

E. Heating and Ventilation: Furnish heating and ventilating system to maintain inside temperature between 50 and 100 degrees F. Provide a 585 CFM exhaust fan with exterior FRP hood. Provide a 1500W wall mounted unit heater. Provide a 10 inch by 10 inch. Any fans or heating equipment provided to maintain temperature shall be suitable from 120V or 208V operation and powered from the load center provided with the enclosure.

F. Fire Protection: Furnish dry chemical fire extinguishers in accordance with NFPA 10.

G. Electrical Systems:

1. The electrical components shall meet applicable requirements of Section 26 05 01, Electrical. All electrical shall be in accordance with National Electrical Code.

2. Install products in accordance with manufacturers' instructions and recommendations.
3. Load Center: The building shall be equipped with an electrical load center to distribute power to the various components that are provided as part of the fabricated building. In addition the load center will provide breakers for the alum feed system pumps as indicated in the load center panel schedule. The load center shall be 120/208V, three-phase load center with a 125A main circuit breaker. Load center shall be in NEMA 4X enclosure. Provide circuit breakers as shown in load center panel schedule. Breaker sizes for any fan, heater or HVAC equipment provided with enclosure are preliminary. Coordinate breaker requirements with HAVC equipment supplied.
4. Illumination Level: At 36 inches above floor, 50 footcandles minimum from LED luminaries. Provide a minimum of two vapor tight LED fixtures. Fixture shall be enclosed and gasketed with fiberglass housing and high impact resistant acrylic diffuser. Provide light switch at door to control lights.
5. Provide two 15A, 120V GFCI duplex receptacles for pumps with one spare outlet.
6. Receptacles, lights, fan, and heater shall be prewired to load center. Provide all internal wiring and conduit runs to the various ancillary equipment supplied with the package.
7. Use EMT conduit for internal wiring.

H. Colors: As selected by Owner.

2.04 MATERIALS

A. Fiberglass Reinforced Plastic: Building shall be constructed using dual shell fiberglass reinforced plastic using a premium grade, isophthalic polyester resin. Gelcoat shall have UV inhibitors, grey cloud color with textured finish.

B. Foam Core: Insulation shall be 1-inch thick polyisocyanurate. Minimum R-7.

C. Structure shall have an internal mounting flange with neoprene rubber gasket.

D. Structure shall be equipped with removeable stainless steel lifting eyes.

E. Fiberglass: Meet requirements of Voluntary Product Standard PS-15.

F. Sealant: Single part polyurethane or silicone meeting ASTM C920, Type S, Grade NS, Class 25.

G. Doors, Frames, and Hardware: Manufacturer's standard. Doors shall have a double, 36-inch by 84-inch doors constructed of FRP. Hinges shall be a Type 304 stainless steel strap hinge. Door latch shall be lockable, Type 316 stainless steel.

H. Door sweep shall have an aluminum flange with neoprene seal.

I. Finishes: Manufacturer's standard.

2.05 SOURCE QUALITY CONTROL

A. Inspections: Before shipment, inspect for complete, functional assembly.

B. Tests: Perform manufacturers' standard tests and adjustments on mechanical and electrical equipment and other moving and operating components.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine Site and access to determine effect on proposed building.

B. Investigate soils conditions and their effect on proposed building.

3.02 PREPARATION

A. Verify Site conditions and make necessary field measurements.

B. Perform Site modifications to suit installation of prefabricated building.

C. Construct foundation.

3.03 ERECTION

A. Erect structure in accordance with manufacturer's instructions. Securely anchor to concrete foundation.

B. Provide for erection and wind loads. Provide temporary bracing to maintain structure plumb and in alignment until completion of permanent, stable structure.

C. Install materials following manufacturers' instructions and recommendations.

3.04 FIELD FINISHING

A. Do not paint electrical equipment.

3.05 HEATING AND VENTILATING

A. Install equipment and components following manufacturer's instructions and recommendations.

B. Meet requirements of NFPA 90A and NFPA 90B.

C. Adjust for proper operation and control.

3.06 ELECTRICAL SYSTEMS

A. Electrical components shall be factory installed and ore-wired by the manufacturer. All components added by the Contractor shall be installed in accordance with Division 26, Electrical of these Specifications.

B. Meet requirements of National Electrical Code, NFPA 70.

C. Install products in accordance with manufacturers' instructions and recommendations.

D. Load Center Panel Schedule will have a minimum on the following loads:

1. Two 15A circuit breakers for duplex GFCI outlets for pumps.
2. Two 15A circuit breakers for lighting.
3. One circuit breaker for 1500W heater.
4. One circuit breaker for Ventilation fan.
5. One spare circuit breaker.

3.07 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on moving and operating components.

B. Performance Tests: Test HVAC system.

C. Electrical Continuity: Test continuity of completed metal structure and installed equipment to ground.

3.08 MANUFACTURER'S SERVICES

A. Provide manufacturers' representatives at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

3.09 CLEANING/ADJUSTING

A. Adjust moving and operating components for smooth operation.

B. Thoroughly clean interior and exterior of building and leave weathertight and ready for use.

3.10 PROTECTION

A. Protect installed products from damage.

END OF SECTION

SECTION 22 07 00
PLUMBING PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy-Efficient Design of New Buildings except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C533, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   c. C534, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   d. C547, Standard Specification for Mineral Fiber Pipe Insulation.
3. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.

1.02 SUBMITTALS

A. Action Submittals: Product description, include list of materials, thickness for each service scheduled, and locations.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Manufacturer’s installation instructions.

1.03 QUALITY ASSURANCE

A. Provide standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

C. UL Listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Deliver insulation, jackets, cements, adhesives and coatings with a manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation Packages and Containers: Mark "asbestos-free."

PART 2 PRODUCTS

2.01 GENERAL

A. Insulation Exterior: Cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for Fittings, Flanges, and Valves: Premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Provide noncombustible insulation, adhesives, vapor barrier materials and other accessories, except as specified herein.
2. Use no fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration as a result of effects of moisture or high humidity are not acceptable.
4. Fire Hazard Rating for Materials including Facings, Mastics, and Adhesives: Not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with NFPA 255 methods.
5. Materials exempt from fire-resistant rating:
   a. Nylon anchors.
   b. Treated wood inserts.
6. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:
   a. Polyurethane insulation.
   b. PVC casing.
   c. Fiberglass-reinforced plastic casing.

2.02 PIPE INSULATION

A. Type P1—Fiberglass (ASTM C547, Type 1 (Minus 20 Degrees F to 500 Degrees F):

1. Fiberglass, UL-rated, preformed, sectional rigid, minimum 4 pounds per cubic foot (pcf) density, K factor 0.23 maximum at 75 degrees F mean, with factory-applied all-service jacket (ASJ) composed of reinforced kraft paper and aluminum foil laminate. Provide jacket with self-sealing lap to facilitate closing longitudinal and end joints.
2. Manufacturers and Products:
   a. CertainTeed; Preformed Pipe Insulation.
   b. Johns Manville; Micro-Lok HP-T.
   c. Owens/Corning; Fiberglas Pipe Insulation.
   d. Knauf Pipe Insulation; Crown Pipe Insulation.

B. Type P3—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water Vapor Transmission: 0.1 perm-inch, or less.
4. Manufacturers and Products:
   a. Armacell; AP Armaflex.
   b. Nomaco; K-Flex LS.

2.03 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 150 degrees F.
2. Manufacturers and Products:
   a. Johns Manville; Zeston.
   b. Ceel-Co; 550.

B. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturer and Product: Armstrong; WB Armaflex finish.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.

2. Moisture Barrier: Provide factory-applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one- or two-piece covers, which includes elbows, tee/valves, endcaps, mechanical line couplings, and specialty fittings.
4. Manufacturer and Product: RPR Products; INSUL-MATE.

D. Type F5—Pit Wrap Jacket:

1. Heat sealing multi-laminate protection system for protection of underground cellular glass insulation.
2. Provide and install in accordance with cellular glass manufacturer's instructions.
3. Manufacturer and Product: Pittsburgh-Corning; PITTWRAP.

PART 3 EXECUTION

3.01 INSTALLATION OF INSULATION

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

K. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

L. Insulate valve bodies, flanges, and pipe couplings.

M. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

N. Do not insulate flexible pipe couplings and expansion joints.

O. Do not allow insulation to cover nameplates or code inspection stamps.

P. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

Q. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

R. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

S. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

T. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

U. Roof Drains: Insulate vertical drops from roof drain to horizontal pipe, exposed and concealed horizontal piping, and 2 feet down on vertical risers from horizontal pipe.

V. Roof and Overflow Drain Sumps: Insulate underside.

W. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal exterior joints to make watertight.

3.03 INSULATION APPLICATIONS

A. Potable Cold Water:

1. Type P3, elastomeric.
2. 1-inch thickness for all pipe sizes.

B. Potable Hot Water:

1. Type P1, fiberglass.
2. 1-inch thickness for all pipe sizes.

C. Pipe Hangers:

1. Type P1, Fiberglass: UL-rated, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 10 inches in length, with factory-applied, vinyl-coated and embossed vapor barrier jacket with self-sealing lap.

2. Type P3, Elastomeric: Rigid insulation section with 9-inch-long, 16-gauge galvanized steel saddle.

3.04 INSULATION FINISH APPLICATIONS

A. Piping Insulation (Concealed Areas): Factory finish.

B. Piping Insulation (Exposed to View, Indoors): Type F1, PVC.

C. Piping Insulation (Outdoors):

1. Type F2, paint (for use with Type P3, elastomeric).
2. Type F3, aluminum.

D. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.05 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

END OF SECTION

SECTION 22 10 01
PLUMBING PIPING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA):
   a. B109.1, Diaphragm Type Gas Displacement Meters (under 500 Cubic Feet Per Hour Capacity).
   b. B109.2, Diaphragm Type Gas Displacement Meters (500 Cubic Feet Per Hour Capacity and Over).
2. American National Standards Institute (ANSI).
3. American Public Works Association (APWA): Uniform Color Code.
4. American Society of Sanitary Engineering (ASSE):
   a. 1010, Performance Requirements for Water Hammer Arresters.
   b. 1050, Performance Requirements for Stack Air Admittance Valves for Sanitary Drainage Systems.
   c. 1070, Performance Requirements for Water Temperature Limiting Devices.
5. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   d. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A179/A179M, Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes.
   g. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   j. A197/A197M, Standard Specification for Cupola Malleable Iron.

k. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
l. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
m. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
n. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
o. A536, Standard Specification for Ductile Iron Castings.
p. A563, Standard Specification for Carbon and Alloy Steel Nuts.
q. A861, Standard Specification for High-Silicon Iron Pipe and Fittings.
r. A888, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
s. B32, Standard Specification for Solder Metal.
t. B61, Standard Specification for Steam or Valve Bronze Castings.
u. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
v. B75/B75M, Standard Specification for Seamless Copper Tube.
w. B88, Standard Specification for Seamless Copper Water Tube.
x. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
y. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
z. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
aa. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
bb. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
cc. B306, Standard Specification for Copper Drainage Tube (DWV).
dd. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
ee. C1277, Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
ff. C1460, Standard Specification for Shielded Transition Couplings for use with Dissimilar DWV Pipe and Fittings Above Ground.
gg. C1540, Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
hh. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

ii. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
jj. D2000, Standard Classification System for Rubber Products in Automotive Applications.
kk. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
ll. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
mm. D2513, Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
nn. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
oo. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
pp. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
qq. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
rr. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
ss. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
tt. E438, Standard Specification for Glasses in Laboratory Apparatus.
uu. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
vv. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
ww. F1412, Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems.
xx. F1924, Standard Specification for Plastic Mechanical Fittings for Use on Outside Diameter Controlled Polyethylene Gas Distribution Pipe and Tubing.
yy. F1973, Standard Specification for Factory Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide 11 (PA11) and Polyamide 12 (PA12) Fuel Gas Distribution Systems.

6. American Water Works Association (AWWA):
   a. C104/A21.4, Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.

c. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
d. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
e. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast.
f. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines, Enamel and Tape, Hot-Applied.
g. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
h. C606, Grooved and Shouldered Joints.
i. C651, Disinfecting Water Mains.

7. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
   b. 310, Specification for Couplings for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Strom Drain, Waste, and Vent Piping Applications.
8. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
9. Plumbing and Drainage Institute (PDI): WH 201, Water Hammer Arresters Standard.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following: Local plumbing code.

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets.
2. Shop Drawings:
   a. Show Contractor recommended changes in location of fixtures or equipment.
   b. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. Isometric riser diagrams showing locations of supports, hangers, valves, equipment and elevations.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Changes in location of equipment or piping that affect connecting or adjacent work, before proceeding with the work.
3. Complete list of products proposed for installation.
4. Test records produced during testing.
5. For Polyethylene (PE) Pipe:
    a. Certificates of qualification for persons to be fusing PE pipe.
    b. Experience and training record of persons to be fusing PE pipe.
    c. Testing Plan:
        1) Submit at least 15 days prior to testing; include following as a minimum:
            a) Testing dates.
            b) Piping systems and section(s) to be tested.
            c) Method of isolation.
            d) Method of conveying water from source to system being tested.
    d. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
    e. Test report documentation.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

B. Natural gas piping installed within buildings and up to 5 feet beyond exterior walls shall meet 2012 International Fire Code.

2.02 PIPING

A. Piping Schedule: Refer to Section 40 27 00, Process Piping—General and see Drawings, Plumbing legend.

B. Piping Material: Refer to Piping Data Sheet(s), Article Supplements and Section 40 27 00, Process Piping—General.

C. Thermoplastic Piping, Tubing, and Fittings: Installation of thermoplastic piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 18 inches below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated. Installations must be made using qualified procedures, by qualified installers, and in compliance with AGA XR0603 and International Fire Code, and must be inspected by a qualified inspector. Provide an electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape shall be buried with the plastic pipe to facilitate locating. One end of the tracer wire or tape shall be brought aboveground at a building wall or riser.

2.03 HOSE VALVES AND HYDRANTS

A. HV-1, Wall Hydrant:

1. Nonfreeze box type with chrome-plated face, integral vacuum breaker, bronze casing, T-handle key, and 3/4-inch inlet and hose connection.
2. Manufacturers and Products:
   a. J. R. Smith; Figure 5509.
   b. Josam; 71000 Series.

2.04 PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

2.05 INSULATION

A. As specified in Section 22 07 00, Building Mechanical Thermal Insulation.

2.06 VALVES

A. Refer to Section 40 27 02, Process Valves and Operators.

B. Balancing Valves (Recirculating Hot Water):

1. Bronze, calibrated balancing type with provisions for connecting a portable differential pressure meter. Meter connections shall have built-in check valves.
2. An integral pointer shall register degree of valve opening.

3. Construct with internal seals to prevent leakage around rotating element.
4. Rated for 125 psig working pressure at maximum temperature of 250 degrees F.
5. Furnish one pressure gauge type readout meter in carrying case.
6. Furnish with preformed polyurethane insulation valve enclosure, suitable for use on hot water systems.
7. Manufacturers and Products:
   a. Bell & Gossett; No. CB circuit setter.
   b. TACO; Series 790.

C. Pressure Reducing Valve, Natural Gas and Propane, 2 psi to 11-Inch WC:

1. Direct diaphragm, spring controlled cast-iron body, spring aluminum diaphragm and spring case, nitrile disc/diaphragm/O-rings, internal relief, NPT thread ends, 125-psig rated.
2. Size/Rating: Size per Drawings, inlet pressure of 2 psig, outlet pressure set at 11-inch water column or as required by equipment connection.
3. Manufacturer and Product: Fisher; S201.

D. Gauge Cock Valves 1/8 Inch to 3/8 Inch:

1. Bronze body, hexagon male and female ends, and tee head.
2. Rated for 125-pound SWP.
3. Manufacturers and Product:
   a. Ernst Gage Co.
   b. Lunkenheimer.

E. Manual Air Vent Valves:

1. With coin-operated air vent.
2. Manufacturers and Products:
   a. Bell & Gossett; No. 4V.
   b. Dole; No. 9.

F. Point of Use Thermostatic Mixing Valve Assembly (3/8-inch Under Sink):

1. Function: Provide tempered water at 0.5 gpm to 2.25 gpm.
2. Listed per ASSE 1070. Bronze body, lead free construction rated to 150 psig maximum inlet pressure.
3. Inlets: One each, 3/8-inch compression fittings, cold and hot water.
4. Outlet: 3/8-inch compression fittings.
5. Self-contained; no electrical requirements.
6. Performance: With 120 degrees F to 180 degrees F hot inlet and 39 degrees F to 85 degrees F cold inlet, deliver 80 degrees F to 10 degrees F at inlet pressures between 30 psig and 100 psig.
7. Set outlet at 110 degrees F maximum unless otherwise noted.

8. Manufacturers and Products:
    a. Watts; LFUSG-B-M2.
    b. Powers; LFe480.
    c. Leonard Valve; Model 170-LF.

G. Point of Use Emergency Thermostatic Mixing Valve Assembly (1/2 Inch):

1. Function: Provide tempered water at 2 gpm to 10 gpm.
2. Listed per ASSE 1071. Bronze body, lead free construction rated to 125 psig maximum inlet pressure.
3. Integral thermometer with local indication.
4. Inlets and Outlet: 1/2-inch NPT.
5. Angle check-stop valves on inlets.
6. Compliance with ANSI Z358.1.
7. Self-contained; no electrical requirements.
8. Performance: With 120 degrees F to 180 degrees F hot inlet and 39 degrees F to 85 degrees F cold inlet, deliver 80 degrees F to 100 degrees F at inlet pressures between 30 psig and 100 psig.
9. Set outlet at 85 degrees F.
10. Manufacturers and Products:
    a. Leonard Valve Co.; TA-300-LF.
    b. Haws; Model 9201EW.

H. Thermostatic Mixing Valve Assembly:

1. Function: Provide tempered water at 3 gpm to 50 gpm.
2. Components:
    a. High flow mixing valve for 15 gpm to 50 gpm.
    b. Low flow mixing valve for 3 gpm to 7 gpm.
    c. Pressure reducing valve.
    d. Pressure gauge.
    e. Isolation valve.
    f. Thermometer.
    g. Pipe fittings.
    h. Heavy-gauge steel cabinet with access door and manufacturer's standard baked enamel finish.
3. Inlets: One each, 3/4-inch NPT, cold and hot water.
4. Outlets: 1-inch NPT.
5. Self-contained; no electrical requirements.
6. Performance: With 140 degrees F hot inlet and 60 degrees F cold inlet, deliver 100 degrees F at inlet pressures between 30 psig and 100 psig. Set outlet at 95 degrees F.
7. Manufacturers and Products:
    a. Powers Process Controls; Series 430/420 Hydroguard.
    b. Leonard; Model TM 850.

2.07 MISCELLANEOUS PIPING SPECIALTIES

A. Strainers for Water Service:

1. Iron body, Y-pattern, 125-pound rated, with screwed bronze or bolted iron cap.
2. Screen: Heavy-gauge stainless steel or monel, 30 mesh.
3. Manufacturers and Products:
   a. Crane; No. 988-1/2.
   b. Mueller; No. 758.

B. Flexible Connectors for Stainless Steel Gas Lines:

1. Corrugated, Type 316 stainless steel hose, with 10-inch live length and Type 316 stainless steel male NPT pipe connectors at each end.
2. Manufacturers and Product:
   a. Flexonics; Braided Rex-Weld.
   b. Kin-Line.

C. Vacuum Breakers 2 Inches and Smaller:

1. Angle type, as required.
2. Manufacturers:
   a. Febco.
   b. Watts.

D. Water Hammer Arresters:

1. Materials: ASSE 1010 certified, Type L copper tube, HHPP piston with two lubricated EPDM O-rings, FDA approved lubricant, rolled piston stop, wrought copper male thread adapter.
2. Manufacturers and Products:
   a. Sioux Chief Mfg. Co., Inc.; Series 650 and 660.
   b. Precision Plumbing Products, Inc.

E. Water Hose:

1. Furnish one 50-foot length(s) of 3/4-inch EPDM black cover and EPDM tube, reinforced with two textile braids. Furnish each length with brass male and female NST hose thread couplings to fit hose nozzle(s) and hose valve(s) specified.
2. Rated minimum working pressure of 200 psi.
3. Manufacturers:
   a. Goodyear.
   b. Boston.

F. Sleeves:

1. Manufacturers and Products:
   a. J. R. Smith; Figure 1720.
   b. Josam; No. 26400.

G. Flashing Sleeves for Roof Penetrations:

1. Built-Up Bituminous Roofing: Fabricate of lead as specified in Section 07 62 00, Sheet Metal Flashing and Trim.
2. Single-Ply Membrane Roofing: Pipe seals as specified in Section 07 70 01, Roof Specialties and Accessories.

H. Insulating Dielectric Unions and Flanges:

1. Galvanically compatible with piping to which attached and pressure ratings suitable for system working pressures.
2. Unions 2 Inches and Smaller: Screwed or solder-joint type.
3. Unions 2-1/2 Inches and Larger: Flanged type, complete with bolt insulators, dielectric gasket, bolts, and nuts.
4. Manufacturers:
   a. Epco Sales, Inc., Cleveland, OH.
   b. Capitol Insulation Unions.

I. Natural Gas Risers: Provide manufacturer's standard anodeless riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide bracket or wall-mounted riser supports.

J. Joint Solder: 95-5 wire solder, ASTM B32, Grade 95 TA. Lead free, NSF certified. Do not use cored solder.

K. Pipe Joint Sealer: Compound insoluble in water or Teflon tape; approved by NFS for use in potable water.

L. Rubber Gaskets: ASTM C564.

2.08 MEASURING DEVICES

A. Thermometers:

1. Adjustable angle, organic spirit type, blue in color, with 9-inch case and scale range in degrees F, as shown.
2. Furnish with 3-1/2-inch stem length and separable NPT brass thermowell.

3. Manufacturers and Product:
   a. Trerice Co.; Model A005.
   b. Weksler.

B. Pressure Gauges:

1. Construction: 3-1/2-inch gauge size, 0 kPa to 690 kPa, 0 psi to 160 psi range, steel case, glass crystal, brass movement, and 1/4-inch NPT lower connection.
2. Furnish with 1/4-inch brass gauge cock.
3. Manufacturers and Products:
   a. Ashcroft; Type 1008.
   b. Marsh; J80.
   c. Marshalltown.

PART 3 EXECUTION

3.01 GENERAL

A. Install plumbing systems to meet applicable plumbing code.

B. Field Obstructions:

1. Drawings do not attempt to show exact details of piping. Provide offsets around obstructions.
2. Do not modify structural components, unless approved by Engineer.

C. Sleeves:

1. Pipe sizes shown are nominal sizes, unless shown or specified otherwise.
2. Provide piping passing through walls, floors, or ceilings with standard-weight pipe sleeves.
3. Provide pipes passing through finished walls with chrome-plated canopy flanges.
4. Dry pack sleeves in existing work in-place and provide finished appearance.
5. Pack holes left by removal of existing piping with grout and finish to match adjacent surface.

D. Provide unions in piping systems at connections to equipment.

E. Provide shielded transition couplings, insulating dielectric unions and flanges between ferrous and nonferrous piping and where otherwise required for electrically insulated connection.

F. Pipe air release valves, water-lubricated bearings, and other appurtenances having water effluent with copper tubing to nearest drain.

G. Provide isolation valves and strainers at pressure regulators.

H. Trench Excavation and Backfill: As specified in Section 31 23 16, Excavation and Section 31 23 23.15, Trench Backfill.

3.02 INSTALLATION

A. Steel Pipe:

1. Ream, clean, and remove burrs and mill scale from piping before making up.
2. Seal joints with pipe joint sealer or Teflon tape.

B. Copper Tubing:

1. Cut tubing square and remove burrs.
2. Clean both inside of fittings and outside of tubing with steel wool and hydrochloric acid before soldering.
3. Prevent annealing of fittings and hard-drawn tubing when making connections.
4. Do not use mitered joints for elbows or notching of straight runs of pipe for tees.

C. Rigid PVC or CPVC:

1. Cut, make up, and install in accordance with pipe manufacturer's recommendations.
2. Ream, clean, and remove burrs from cut ends before joining pipe.
3. Lay in trench by snaking pipe from one side to other.
4. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and final use.
5. Do not lay pipe when temperature is below 40 degrees F or above 90 degrees F when exposed to direct sunlight.
6. Shield ends to be joined from direct sunlight prior to and during laying operation.
7. Use strap wrenches only for tightening threaded plastic joints. Do not over tighten fittings.

D. Polyethylene Piping for Natural Gas:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.

2. Perform butt-fusion in accordance with pipe manufacturer's recommendations as to equipment and technique.
3. Lay pipe snaking from one side of trench to other.
4. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
5. Do not lay pipe when temperature is below 40 degrees F or above 90 degrees F when exposed to direct sunlight.
6. Shield ends to be joined from direct sunlight prior to and during laying operation.
7. Joint Fusion:
    a. Measure and log each joint fusion by an electronic monitoring device (data logger) affixed to fusion machine capable of being retrieved electronically. Data to be logged shall include the following:
        1) Pipe size and dimensions.
        2) Machine model and size.
        3) Operator identification.
        4) Job identification number.
        5) Weld number.
        6) Fusion, heating, and drag pressure settings.
        7) Heater plate temperature.
        8) Time stamp showing when weld was performed.
        9) Heating and curing time of weld.
        10) Curing temperature readings and time stamps of readings.
        11) Error messages and warnings for out of range temperature or pressure settings.
    b. In addition to logged items above, the following shall be logged or annotated on report:
        1) Location of fused joint by pipeline station or by reference to pipe Shop Drawing.
        2) Ambient temperature and humidity.
        3) If internal bead was removed.
8. Installation of thermoplastic piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 18 inches below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated. Installations must be made using qualified procedures, by qualified installers, and in compliance with AGA XR0603 and International Fire Code, and must be inspected by a qualified inspector. Provide an electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape shall be buried with the plastic pipe to facilitate locating. One end of the tracer wire or tape shall be brought aboveground at a building wall or riser.
9. Connections Between Metallic and Plastic Piping: Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

10. Aboveground Piping: Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than 6 inches from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.
11. Final Gas Connections: Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Flexible connectors may be used for final connections to gas utilization equipment. In addition to cautions listed in instructions required by ANSI standards for flexible connectors, insure that flexible connectors do not pass through equipment cabinet. Provide accessible gas shutoff valve and coupling for each gas equipment item.
12. Thermoplastic Joints: Conform jointing procedures to AGA XR0603. Do not make joints with solvent cement or heat of fusion between different kinds of plastics.
13. PE Fusion Welding Inspection: Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect, in conformance with API 570, 100 percent of all joints and re-inspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.
14. Joining Thermoplastic to Metallic Piping or Tubing: When compression type mechanical joints are used, provide gasket material in the fittings compatible with the plastic piping and with the gas in the system. Use an internal tubular rigid stiffener in conjunction with the fitting, flush with end of the pipe or tubing, extending at least to the outside end of the compression fitting when installed. Remove all rough or sharp edges from stiffener. Do not force fit stiffener in the plastic. Split tubular stiffeners are not allowed.

E. Water System Balancing: Provide a qualified registered engineer or firm specializing in testing and balancing to adjust domestic water system. Balance system for required water flows at each plumbing fixture, terminal device, and recirculating hot water loop.

F. Water Hammer Arresters:

1. Install in piping systems where shown on Drawings and adjacent to pieces of equipment where quick closing valves are installed.
2. Install at all emergency safety showers and eyewashes.
3. Size and install in accordance with PDI-WH201.
4. Shock arresters to have access panels or to be otherwise accessible.

G. Valves:

1. Shut off valve: Install the main gas shutoff valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled. Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide PE piping manufacturer bracket support assembly securely fastened to structure for valve connections to resist operating torque applied to PE pipes. Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

H. Miscellaneous Piping Specialties: Install in accordance with manufacturer’s recommendations.

I. Measuring Devices: Install in accordance with manufacturer’s recommendations.

J. Line and Appliance Pressure Regulators: Install line pressure regulators and appliance regulators in accordance with the manufacturer's requirements and in accordance with International Fire Code. Install each regulator in an accessible location and install shutoff valves ahead of each line and appliance regulator to allow for maintenance. Where vent limiting devices are not included in the regulators, install a vent pipe to the exterior of the building. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.03 SANITARY AND WASTE DRAINS AND VENTS PIPING

A. Installation:

1. Set piping above floor slab true and plumb.
2. Set exposed risers as close to walls as possible.
3. Slope drain lines at minimum 2 percent slope, unless otherwise noted. Vent lines shall be installed level or sloped, with no low spots.
4. Where vent stacks pass through roof slab, fit with flashing sleeve secured to roof.
5. Extend vents minimum 1 foot above roof.
6. Provide cleanouts where shown and where required by code.

3.04 ACID-RESISTANT DRAINS AND VENTS

A. Install in accordance with manufacturer’s recommendations.

B. Drainage Vents: Same piping system as used for acid-resistant drains.

C. Make connections between polypropylene piping systems and other acid-resistant drainage systems with adapters recommended by manufacturer.

D. Buried Polypropylene Pipe:

1. Heat join and test for leakage before placing in trench.
2. Snake slightly on long runs placed in trench.
3. When installed in extremely hot or cold weather, make proper allowance for expansion or contraction.

E. Buried Acid-Resistant Cast Iron Pipe With Teflon-Lined Couplings:

1. Install in accordance with manufacturer's instructions.
2. Do not allow acid waste to contact pipe and Teflon until installation is complete and tested.

F. Buried Polypropylene Drain and Vent Pipe:

1. Install in accordance with manufacturer's recommendations.
2. Trench shall have a clean sand bed graded to proper pitch.
3. Completely cover pipe with clean sand prior to backfilling.
4. Compact sand by flooding with water.
5. Do not permit sharp stones in backfill surrounding pipe.

3.05 HVAC CONDENSATE PIPING

A. Set piping true and plumb.

B. Slope piping 1/8 inch per foot minimum.

3.06 WATER SUPPLY PIPING

A. Water supply piping includes potable (W1), laboratory potable water (LW1), laboratory hot water (LHW), laboratory hot water return (LHWR), hot water (HW), hot water return (HWR), and tepid water (TW) systems.

B. Flush water piping systems clean of internal debris, clean faucet aerators, and adjust plumbing fixture valves for manufacturer's recommended flow.

C. Do not run water piping through electrical rooms, stairwells, or immediately over or within a 3-foot horizontal clearance of electrical panels, motor starters, or environmental control panels.

D. Provide exterior water piping with minimum 3 feet of cover or install below frost line, whichever is greater.

E. Hose Valves and Hydrants: Attach handle with setscrew and provide manufacturer's recommended gravel fill around drain hole of post hydrants.

F. Provide valve operators with position indicators, where indicated, to show position of valve disc or plug.

G. Provide bypass with globe valve for emergency throttling around each reducing valve.

H. Protect buried copper and steel pipe and fittings with a single wrap of coal-tar saturated felt in accordance with AWWA C203.

I. Vacuum Breakers 2 Inches and Smaller: Install minimum 6 inches above flood line of equipment they serve.

J. Provide manual air vents at high points in domestic hot water system.

3.07 NATURAL GAS AND PROPANE PIPING

A. Install in compliance with applicable local gas code.

B. If gas is wet, slope piping 1/4 inch per foot downward in direction of flow. Provide drip traps at low spots.

C. Install drip traps at end of runs and where pipe changes elevation.

D. Provide dirt leg, ground union joint, and isolation valve adjacent to each flexible connector hose at each appliance connection.

E. Label "NATURAL GAS, X PSIG", or "PROPANE, X PSIG" at intervals not to exceed 5 feet, indicating fuel type and pressure.

3.08 INSULATION

A. As specified in Section 22 07 00, Plumbing Piping Insulation.

3.09 HANGERS AND SUPPORTS

A. In accordance with Section 40 05 15, Piping Support Systems.

B. Install pre-engineered support equipment in accordance with manufacturer's recommendations.

C. Hanger Rod Sizing and Spacing for:

1. Steel Pipe:

Pipe Size	Max. Hanger Spacing (feet)	Min. Rod Size (inches)
1 inch and smaller	6	1/4
1-1/4 through 2-1/2 inches	8	1/4
3 and 4 inches	10	3/8
6 inches	12	3/8
8 inches	12	1/2

2. Copper Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: 2 feet less per size than for steel pipe, except pipe 1-1/4 inches and smaller shall be supported every 6 feet.
3. Plastic Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: As recommended by manufacturer and required by applicable plumbing code for flow and temperature in pipe.
   c. No metal portion of hanger shall contact pipe directly.

D. Attach Support Rods For Horizontal Piping:

1. To steel beams with I-clamps.
2. To concrete with inserts or with flanges fastened with flush shells.
3. To wood with thickness of 2-1/2 inches or more with bolts or angle clips.

E. Trapeze Hangers:

1. Trapeze hangers may be used in lieu of individual hangers where horizontal piping is arranged with two or more parallel lines.
2. Attach lines to horizontal with U-bolts or one-hole clamps.

F. Vertical Piping:

1. Support by channel type support system and pipe clamps on 10-foot maximum centers.
2. Copper and Plastic Piping: Isolate from channels and pipe clamps with pipe isolators.

G. Insulated Piping: Furnish galvanized protection shield and oversized hangers under insulated piping.

3.10 INSTALLATION—CONCRETE ENCASED

A. Where horizontal piping is encased in concrete such as a floor or equipment slab, rigidly mount pipe to rebar and subbase to prevent lateral movement, sagging, and uplifting during concrete installation and finishing. Provide at least two temporary strut supports wired to rebar and supported from the engineered fill or subbase below for each section of pipe.

B. Where construction joints occur, or piping leaves concrete encasements at buildings, utility trenches, vaults, slabs and other structures, provide elastomeric foam insulation wrap around the pipe at the transition point.

1. Minimum Wrap: five pipe diameters of 1/2-inch-thick insulation on each side of the transition.

C. Provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.11 INTERIM CLEANING

A. As specified in Section 40 27 00, Process Piping—General.

B. Prevent accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material within piping during fabrication and assembly.

C. Examine piping to assure removal of foreign objects prior to assembly.

D. Conventional commercial cleaning methods of cleaning are acceptable if method and cleaning material does not corrode, deform, swell, or otherwise alter physical properties of material being cleaned.

3.12 TESTING

A. General:

1. Conduct pressure and leakage tests on newly installed pipelines.
2. Provide necessary equipment and material, and make taps in pipe, as required.
3. Test Pressures: As specified herein and in Piping Schedule.
4. Test Records: Make records of each piping system installation during test to document the following:
    a. Date of test.
    b. Description and identification of piping tested.
    c. Test fluid.
    d. Test pressure.

e. Remarks, including:
   1) Leaks (type, location).
   2) Repairs made on leaks.
f. Certification by Contractor and signed acknowledgment by Engineer that tests have been satisfactorily completed.

B. Testing New Pipe Connected to Existing Pipe: Isolate new pipe with grooved end pipe caps, spectacle blinds, or blind flanges.

C. Preparation and Execution:

1. Buried Pressure Piping:
   a. An initial service leak test may be conducted with a partially backfilled trench and the joints left open for inspection, if field conditions permit, as determined by Engineer.
   b. Expose joints for the acceptance test on buried pressure piping to be pneumatically tested or subjected to an initial service leak test.
   c. Conduct final hydrostatic acceptance tests after trench has been completely backfilled.
2. Exposed Piping: Conduct tests after piping has been completely installed including supports, hangers, and anchors, but prior to insulation.

D. Hydrostatic Leak Tests:

1. Equipment: Provide the following:

Amount	Description
2	Graduated containers
2	Pressure gauges
1	Hydraulic force pump
	Suitable hose and suction pipe as required

2. Procedure:
   a. Use water as the hydrostatic test fluid.
   b. Provide clean test water of such quality as to minimize corrosion of the materials in the piping system.
   c. Open vents at high points of the piping system to purge air pockets while the piping system is filling.
   d. Venting during filling of system may also be provided by loosening flanges with a minimum of four bolts or by the use of equipment vents.
   e. Test piping systems at test pressure specified in Piping Schedule.

f. Maintain hydrostatic test pressure continuously for 30 minutes minimum and for such additional time as necessary to conduct examinations for leakage.
g. Examine joints and connections for leakage.
h. Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking.
i. Correct visible leakage and retest to satisfaction of Engineer.

3. Buried Water Lines:
   a. A limited amount of leakage is permissible according to formula specified.
   b. Conduct hydrostatic testing as follows:
      1) Pipe with Concrete Thrust Blocking: Do not make pressure test until a minimum of 5 days after thrust blocking is installed.
      2) If high-early strength cement is used for thrust blocking, time may be reduced to 2 days.
   c. Cement-Lined Piping: Slowly fill test section with water and allow to stand for 24 hours under slight pressure to allow cement lining to absorb water.
   d. Expel air from piping system prior to testing.
   e. Apply and maintain specified test pressure with hydraulic force pump.
   f. Valve off the piping system when test pressure is reached.
   g. Conduct pressure test for 2 hours, reopening isolation valve only as necessary to restore test pressure.
   h. Accurately measure amount of water required to maintain test pressure by placing pump suction in a barrel or similar device, or by metering.
   i. The measurement represents leakage, defined as the quantity of water necessary to maintain the specified test pressure for the duration of the test period.
   j. Determine maximum allowable leakage in gallons per hour from the following formula:

$$L = \frac{ND(P)^{1/2}}{7400}$$

where:

L = Allowable leakage, in gallons per hour
N = Number of joints in the length of pipe tested
D = Nominal diameter of pipe, in inches
P = Test pressure during the leakage test, in pounds per square inch

k. Correct leakage greater than the allowable determined under this formula, and retest to satisfaction of Engineer.

4. Test Pressure for Water: 1-1/2 times system pressure.
5. Gravity Sewers and Drains:
   a. Test by water or air exfiltration tests as prescribed by local or state plumbing codes and visually examine for leaks.
   b. Repair leaks and retest system until no further leakage is evident.

E. Pneumatic Leak Tests:

1. Perform on compressed air, natural gas, and vacuum piping.
2. Equipment: Provide the following:

Amount	Description
1	Pneumatic compressor separator-dryer system capable of providing oil-free dry air and equipped with one or more full capacity safety relief valves set at a pressure of not more than 105 percent of the required primary test pressure
1	Calibrated test gauge

3. Procedure:
   a. Perform pneumatic testing using accurately calibrated instruments and oil-free, dry air.
   b. Perform tests only on exposed piping, after piping has been completely installed, including supports, hangers and anchors, and inspected for proper installation.
   c. Test piping system at test pressure specified in Piping Schedule.
   d. Protect test personnel and Owner's operating personnel from hazards associated with air testing.
   e. Secure piping to be tested to prevent damage to adjacent piping and equipment in event of a joint failure.
   f. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by test.
   g. Apply maximum 25 psig preliminary pneumatic test to piping system prior to final leak testing, to locate major leaks.
   h. Examine joints and connections for leakage with soap bubbles.
   i. Correct visible leaks and retest.
   j. Gradually increase pressure in system to not more than one-half of test pressure.
   k. Thereafter increase pressure in steps of approximately 1/10 of maximum test pressure until required test pressure is reached.
   l. Maintain pneumatic test pressure continuously for minimum 10 minutes and for such additional time as necessary to conduct a soap bubble examination for leakage.

m. Piping system, exclusive of possible localized instances at pump or valve packing, shall show no evidence of leakage.
n. Correct visible leakage and retest to satisfaction of Engineer.
o. Following pneumatic testing, thoroughly purge lines that are to carry flammable gases with nitrogen to assure no explosive mixtures will be present in system during filling process.

3.13 CLEANING AND DISINFECTION

A. As specified in Section 33 13 00, Disinfecting of Water Utility Distribution Facilities.

3.14 CORROSION PROTECTION

A. As specified in Section 40 27 00, Process Piping—General.

3.15 BONDING

A. Buried Piping: As specified.

3.16 CATHODIC PROTECTION

A. Buried Piping: As specified.

3.17 PROTECTION OF INSTALLED WORK

A. Protective Covers:

1. Provide over floor and shower drains during construction, to prevent damage to drain strainers and keep foreign material from entering drainage system.
2. Cover roof drains and emergency overflow drains during roofing process so roofing material and gravel do not enter drain piping.
3. Remove at time of Substantial Completion.

3.18 FIELD FINISHING

A. In accordance with Section 40 27 00, Processing Piping—General.

3.19 PIPING IDENTIFICATION

A. Refer to Section 40 27 00, Process Piping—General, and Pipe Schedule.

3.20 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Plumbing Piping Data Sheets.

Section Number	Title
22 10 01.02	Polyvinyl Chloride Drain Waste and Vent (PVC-DWV) Pipe and Fittings
22 10 01.06	Acid-Resistant Polypropylene Waste and Vent Pipe and Fittings
22 10 01.08	High-Density Polyethylene Pipe and Fittings
22 10 01.12	Polyethylene (PE) Pipe and Fittings—Natural Gas Service

END OF SECTION

SECTION 22 10 01.02
POLYVINYL CHLORIDE
DRAIN WASTE AND VENT (PVC-DWV)
PIPE AND FITTINGS

Item	Size	Description
Pipe and Fittings	All	PVC-DWV Schedule 40 nonpressure application, Class 12454B conforming to ASTM D2665 and ANSI/NSF Standard 14 system.
Joints	All	Solvent cemented conforming to ASTM D2855 except where connection to equipment may require future removal.
Solvent Cement	All	As recommended by the pipe and fitting manufacturer conforming to ASTM D2564.

END OF SECTION

SECTION 22 10 01.06
ACID-RESISTANT POLYPROPYLENE WASTE AND VENT PIPE AND FITTINGS

Item	Size	Description
Pipe	All	Polypropylene, ASTM F1412, Type 1, Schedule 40; resin meeting ASTM D4101. Conforming to ASTM D2447, ASTM D635, and ASTM D2843.
Fittings	All	Polypropylene, ASTM F1412, Type 1, Schedule 40, socket type ends conforming to ANSI B16.12, ASTM D2657, and ASTM D4101.
Joints	All	Socket-weld type, electrically fused.
Manufacturers		R & G Sloane Manufacturing Co., Inc. Celanese Piping Systems, Inc. Orion Fittings, Inc.

END OF SECTION

SECTION 22 10 01.08 HIGH-DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS— WATER AND SEWER SERVICE		
Item	**Size**	**Description**
General	All	Pipe lengths, fittings, and flanged connections to be joined by thermal butt-fusion; shall be of the same type, grade, and class of polyethylene compound and supplied from same raw material supplier. Pipe tubing and fittings manufactured in accordance with ASTM D2239.
Pipe	1/2" to 4"	Cell class ASTM D3350 high-density polyethylene, maximum allowable hoop stress 1,600 psi at 73.4 degrees F. Polyethylene Resin: Conform to Type PE 3408 or better. Provide protection against ultraviolet light degradation using carbon black, not less than 2 percent, well dispersed in resin. Pipe wall thickness shall reflect required SDR* and diameter, as shown in Table 8, ASTM F714. For 3" and larger sizes, ASTM D3035. Design Stress Rating: 1,600 psi hydrostatic. Pressure Rating (psi) at 100 degrees F — SDR* 128 — 13.5 100 — 17.0 90 — 19.0 Identification: Colored **[A: stripes extruded into pipe outside surface] [B: marking tape]** for identification of type of service, in accordance with APWA Uniform Color Code. *SDR: standard dimension ratio = OD/thickness
Fittings	4" & smaller	Molded fittings, butt fusion joined, conforming to ASTM D3261.

SECTION 22 10 01.08 HIGH-DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS— WATER AND SEWER SERVICE		
Item	**Size**	**Description**
Flanges	All	Van Stone type, cast ASTM A351/A351M, Type 316 stainless steel backing ring, IPP Deltaflex convoluted design or equal for bolting to ANSI B16.1, Class 125; ANSI B16.5, Class 150; and AWWA C207, Class E. Pressure performance of backing ring equal to SDR rating of pipe with safety factor of two. Stub ends same grade HDPE and pressure rating as pipe.
Bolting		Stainless steel, ASTM A193/A193M Grade B8M studs and ASTM A194/A194M Grade 8M hex head nuts. Washers shall be same material as bolts.
Gaskets		Flat ring, 1/8" ethylene propylene rubber (EPR).
Manufacturer		JM Eagle PE 3408; Driscoplex 4000/4100 PE 3408.

END OF SECTION

SECTION 22 10 01.12
POLYETHYLENE (PE) PIPE AND FITTINGS—
NATURAL GAS SERVICE

Item	Size	Description
General	All	Pipe lengths, fittings, and connections to be joined by thermal fusion; shall be same type, grade, and class of polyethylene compound and supplied from same raw material supplier. Pipe tubing and fittings manufactured in accordance with ASTM D2513.
Pipe	1/2" to 12"	ASTM D2513 medium-density polyethylene, maximum allowable hoop stress 1,250 psi at 73.4 degrees F. Polyethylene Resins: Conform to Type PE 2406/2708 or better. Pipe wall thickness shall reflect required SDR* and diameter, as shown in Table 8, ASTM F714. Design Stress Rating: ASTM F1924, 1,250 psi hydrostatic design basis (HDB). Pressure Rating (psi) at 100 degrees F — SDR* 100 — 7.0 100 — 7.3 100 — 9.0 97 — 9.3 80 — 11.0 64 — 13.5 Note: Installed outdoors and underground only. Operating pressure for natural gas piping shall be limited to 100 psig or less per 2009 IFGC. Identification: Pipe and fittings shall be yellow in color and shall be marked “ASTM D2513”. *SDR: standard dimension ratio = OD/thickness

SECTION 22 10 01.12 POLYETHYLENE (PE) PIPE AND FITTINGS— NATURAL GAS SERVICE		
Item	**Size**	**Description**
Fittings	4" & smaller	Molded Fittings: Conform to PE 2406/2708. Socket Fusion Fittings: Meet requirements of ASTM D2683. Butt Fusion Fittings: Meet requirements of ASTM D3261.
Flanges	All	Flanges not permitted underground. Above ground, flanges and bolting shall be part of approved, listed transition fitting.
Risers and Transitions		Conform to ASTM F1973.
Manufacturer		Pipe: JM Eagle UAC 2000 MDPE yellow gas pipe; Driscoplex 6500 series. Risers and Transitions: Georg Fischer Central Plastics.

END OF SECTION

SECTION 22 30 00
PLUMBING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA).
2. American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. American Society of Mechanical Engineer's (ASME).
4. American Society of Sanitary Engineering (ASSE):
   a. 1013, Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Backflow Preventers.
   b. 1015, Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Backflow Fire Protection Assemblies.
5. American Water Works Association (AWWA):
   a. C510, Double Check Valve Backflow Prevention Assembly.
   b. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   c. C550, Protective Interior Coatings for Valves and Hydrants.
6. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
7. Canadian Standards Association (CSA):
   a. B64.4, Backflow Preventers, Reduced Pressure Principle Type (RP).
   b. B64.5, Backflow Preventers, Double Check Valve Type (DCVA).
8. FM Global (FM).
9. Food and Drug Administration (FDA).
10. Foundation for Cross-Connection Control and Hydraulic Research at University of Southern California (FCCHR): Manual of Cross-Connection Control.
11. International Code Council (ICC): International Plumbing Code (IPC).
12. National Electrical Code (NEC).

13. National Electrical Manufacturers Association, (NEMA): MG 1, Motors and Generators.
14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's product data.
2. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation and Testing.

1.03 SPECIAL GUARANTEE

A. Where note below, provide manufacturer's extended guarantee in writing with Owner named as beneficiary. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of products found defective during the stated period after date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 ELECTRIC WATER HEATER (COMMERCIAL):

A. Description:

1. Automatic, vertical, electric storage type.
2. Regulatory Compliance: UL listed, ASME, ASHRAE 90.1, and NSF.
3. Tank: Steel, glass-lined, 150 psig working pressure, and ASME rate with 4-inch by 6-inch handhole cleanout.
4. Insulation: Foam or fiberglass type with minimum R value per ASHRAE 90.1.
5. Dip Tube: Required on inlet connection down to bottom section of tank.
6. Anode: Heavy-duty, tank-mounted, screw-in type.
7. Pressure/Temperature Relief Valve: ASME rated.
8. Connections: Inlet and outlet with factory-installed dielectric unions and brass drain valve with hose thread.
9. Heating Element: Watt-density (maximum of 75 watts per square inch) incoloy sheath; immersion type.
10. Controls: Fully automatic, house in hinged control panel, and including the following:
    a. Terminal block.
    b. Close differential immersion-type thermostat.
    c. Control transformer for 120-volt circuit and fusing.
    d. Magnetic contactors for each stage.
    e. Manual reset high-limit switch.
    f. Adjustable temperature range, 95 degrees F to 180 degrees F.
    g. Power circuit fusing as required by NEC and UL.
11. Guarantee: 3 years.

B. Capacity: See Plumbing Schedules on Drawings.

1. Manufacturers:
    a. AO Smith.
    b. Bradford White Corporation.
    c. Lochinvar Corporation.

2.03 NATURAL GAS FIRED WATER HEATER (COMMERCIAL)

A. Gas Water Heater:

1. Description:
    a. Type: Automatic, vertical, gas-fired, closed combustion, power direct vent, storage type.
    b. Regulatory Compliance: ASHRAE 90.1.
    c. Tank: Steel, glass-lined, 150 psig working pressure.
    d. Insulation: Foam or fiberglass type with minimum R value of 16.

e. Thermal Trap: Factory installed on inlet and outlet.
f. Dip Tube: Required on inlet connection down to bottom section of tank.
g. Anode: Heavy-duty, tank-mounted, screw-in type.
h. Pressure/Temperature Relief Valve: ASME rated.
i. Connections: Inlet and outlet with factory-installed dielectric unions and brass drain valve with hose thread.
j. Burner: 80 percent efficient, cast iron, with primary air injection.
k. Vent: Modular electric blower, power direct-vent, with 7-foot power three-prong connection. Two-pipe closed combustion system.
l. Vent Material: 3-inch Schedule 40 PVC, CPVC, or ABS pipe. Factory roof intake and vent terminals.
m. Controls: Fully automatic electronic temperature control, push-button pilot igniter.
n. Warranty: 1 year.

2. Capacity: See Plumbing Schedules on Drawings.
3. Manufacturers:
   a. AO Smith.
   b. State.
   c. Lochinvar Corporation.

2.04 GAS VENT STACK

A. For Gas-Fired Water Heaters:

1. UL listed, Type B double wall, insulated gas vent pipe with rain cap.
2. Insulating thimble.
3. Pier section with cleanout where stack is offset.
4. Manufacturer’s standard fittings as required.

B. Manufacturers and Products:

1. Selkirk; Metalbestos.
2. Van Packer.

2.05 DOMESTIC WATER EXPANSION TANK

A. Description:

1. Type: Prepressurized diaphragm type, horizontal or vertical per expansion tank data sheet at end of section.
2. Shell: Welded steel.
3. Diaphragm: FDA-approved, heavy-duty butyl with polypropylene liner.
4. Connection Size: Per expansion tank data sheet at end of section.

5. Maximum Operating Pressure: Per expansion tank data sheet at end of section Plumbing Schedules on Drawings.
6. Maximum Operating Temperature: Per expansion tank data sheet at end of section or Plumbing Schedules on Drawings.
7. Finish: Manufacturer's standard air-dry enamel.
8. Capacity: See data sheet at the end of section or Plumbing Schedules on Drawings.

B. Manufacturer: AMTROL, Inc. or Engineer approved equal.

2.06 DOMESTIC HOT WATER CIRCULATING PUMP

A. Description:

1. Type: In-line, direct-drive, close-coupled centrifugal pump.
2. Construction: Bronze body, stainless steel face plate, glass-filled noryl impeller, carbon steel shaft, mechanical carbon on ceramic seals, and bronze oil lubricated motor bearings.
3. Motor: Permanent split-capacitor with thermal overload protection.
4. Accessories: Aquastat and automatic timer kit.
5. Capacity: See Plumbing Schedules on Drawings.

B. Manufacturers:

1. Bell & Gossett.
2. Taco, Inc.
3. Grundfos Pump Corporation.

2.07 ACID NEUTRALIZATION TANK

A. Description:

1. Cylindrically shaped, bolted nonskid cover, drain inlet, drain outlet, and side vent connection.
2. Tank: Fabricated from polypropylene, ASTM D4101, rated for continuous use up to 212 degrees F.
3. Tank Extension: Provide as required to allow cover to be flush with finished floor.
4. Limestone chips.
5. Capacity: See Plumbing Schedules on Drawings.

B. Manufacturers:

1. Orion Fittings, Inc.
2. Town & Country Plastics.

2.08 BACKFLOW PREVENTERS

A. Reduced Pressure Backflow Preventers (1/4 Inch Through 1/2 Inch):

1. Description:
   a. Regulatory Compliance: AWWA C511, CSA B64.4, ASSE 1013, ICC (IPC), FM, USC-UL.
   b. Valve Body: Bronze.
   c. End Connections: Threaded, NPT.
   d. Maximum Working Pressure: 175 psi (350 psi test).
   e. Temperature Range: 32 degrees to 140 degrees F.
   f. Shutoff Valve: Full port, resilient seated, bronze ball valve with bronze ball valve test cock.
   g. Accessories: Drainline air gap fitting.
2. Sizes: See data sheet at end of section.
3. Manufacturer and Product: Conbraco Industries; Series 20-400.

B. Reduced-Pressure Backflow Preventers (3/4 Inch Through 2 Inches):

1. Description:
   a. Regulatory Compliance: AWWA C511, CSA B64.4, FCCHR of USC Section 10, ASSE 1013, ICC (IPC).
   b. Valve Body: Bronze.
   c. End Connections: Threaded, NPT.
   d. Maximum Working Pressure: 175 psi (350 psi test).
   e. Temperature Range: 32 degrees F to 140 degrees F.
   f. Shutoff Valve: Full port, resilient seated, bronze ball valve with bronze ball valve test cock.
   g. Inlet Strainer: Bronze wye strainer, 40-mesh perforated, Type 304 stainless steel.
   h. Accessories: Drainline air gap fitting.
2. Sizes: See data sheet at end of section.
3. Manufacturers and Products:
   a. Febco; Model 860.
   b. Watts; Model 909.

2.09 ENVIRONMENTAL ENCLOSURES

A. For Backflow Preventers 3/4 Inch to 3 Inches:

1. Description:
   a. Enclosure shall be factory-assembled unit providing heat and accessibility to the system backflow preventers. Unit shall meet the requirements of NFPA and ASSE for testing of the backflow

preventer. Design to protect to minus 30 degrees F. Unit shall be suitable for concrete pad mounting.

b. Adjustable thermostat shall control electric heaters/cables. Set thermostat to maintain 40 degrees F.

c. Fiberglass construction, 1-inch-thick, factory applied unicellular nonwicking insulation, minimum R-value of 8, hinged and lockable access doors. Designed for exterior installation.

2. Heating Capacity:
   a. 3/4-Inch to 1-1/2-Inch: 60-watt heater, 120 volt, single-phase.
   b. 2-Inch: 90-watt heater, 120 volt, single-phase.
   c. 3-Inch: 1500-watt heaters, 120 volt, single-phase.
3. Manufacturers and Products:
   a. Hot Box; Series HB.
   b. Watts.

2.10 ICE MAKER

A. Description:

1. Ice cube machine, 290-pound storage, 30 inches wide by 30 inches deep by 39 inches high with legs and front air circulation.
2. Integral refrigeration system, electronic controls, water pump motor, and water control valve.
3. Factory installed photoelectric eye bin control.
4. Solid state microprocessor electronic controls.
5. Reusable, cleanable air filter.
6. 115 volt, single-phase.

B. Manufacturer: Scotsman; Model SCE-275.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, arrange, and connect equipment as shown on Drawings and in accordance with manufacturer's recommendations.

3.02 FIELD QUALITY CONTROL

A. Pumps: Do not hydrostatic test pumps with mechanical seals.

B. Startup:

1. In accordance with Section 01 91 14, Equipment Testing and Facility Startup, and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

2. Piping Systems: Verify that flushing, cleaning, and testing has been completed prior to startup.

3.03 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is part of this Specification.

1. W3 System - Water Expansion (Bladder) Tank.

END OF SECTION

W3 System - Water Expansion (Bladder) Tank							
Tag Number	**Configuration (horiz/vert)**	**Total Volume (gallons)**	**Acceptance Volume (gallons)**	**Air Pre-charge (psi)**	**Diameter (inches)**	**Height (inches)**	**Manufacturer, Model No.**
32-TNK-0601	Vertical	528	528	100	48	97	Amtrol, Model WX-457C

Note : W3 system bladder tank (32-TNK-0601) will be located in the lower level of the existing Headworks structure. Connection size: 3-inch NPT.

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Americans with Disabilities Act (ADA).
2. American Gas Association (AGA).
3. American Society of Mechanical Engineers (ASME).
4. American Society of Sanitary Engineering (ASSE): 1010, Performance Requirements for Water Hammer Arresters.
5. ASTM International (ASTM): D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
6. Food and Drug Administration (FDA).
7. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
8. Plumbing and Drainage Institute (PDI):
   a. Code Guide 302 and Glossary of Industry Terms.
   b. WH-201, Water Hammer Arrester Standard.
9. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Catalog information and rough-in dimensions for plumbing fixtures, products, and specialties.

1.03 REGULATORY REQUIREMENTS

A. Comply with the Americans with Disabilities Act (ADA), and local and state requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 MANUFACTURERS

A. Fixture Trim:

1. Supply Stops and Traps:
   a. McGuire.
   b. American Standard.
   c. Kohler.
2. Flush Valves: Sloan.
3. Water Closet Seats:
   a. Bemis.
   b. Church.
   c. Olsonite.
4. Lavatory Supply, Tailpiece, and Trap Insulation:
   a. McGuire.
   b. Trap Wrap.
   c. Truebro.

B. Plumbing Fixtures:

1. Water Closets, Lavatories, and Urinals:
   a. American Standard.
   b. Kohler.
   c. Eljer.
2. Service Sinks:
   a. Kohler.
   b. Eljer.

3. Faucet Fittings:
    a. Sinks:
        1) Chicago.
        2) T&S Brass.
    b. Lavatories:
        1) Chicago.
        2) Symmons.
4. Shower Trim:
    a. Symmons.
    b. Powers.
5. Shower Stalls:
    a. Aqua Glass.
    b. Fixture Manufacturers.
6. Stainless Steel Sinks:
    a. Elkay.
    b. Just.
7. Mop Sinks:
    a. Stern-Williams.
    b. Fiat Products Inc.
    c. Fixture Manufacturers.
8. Drinking Fountains and Electric Water Coolers:
    a. Elkay.
    b. Haws.
    c. Western.

C. Emergency Showers and Eyewashes:

1. Haws.
2. Western.
3. Guardian.

D. Drainage Products:

1. General:
    a. Smith.
    b. Wade.
    c. Zurn.
2. Acid Resistant:
    a. Enfield.
    b. R&G Sloane.
    c. T&C Plastic Drain Co.

E. Plumbing Specialties:

1. Shock Arresters:

a. Smith.
b. Sioux Chief.
c. Precision Plumbing Products.

2. Trap Primers:
   a. Precision Plumbing Products.
   b. Smith.
   c. Wade.
3. Pressure/Temperature Relief Valves:
   a. Cash-Acme.
   b. Kunkle Valve.
   c. Watts.
4. Pressure Gauges:
   a. Ashcroft.
   b. Marsh.
   c. Marshalltown.
5. Thermometers:
   a. Trerice.
   b. Weksler.
6. Automatic Washer Supplies:
   a. Guy Gray.
   b. Symmons.

2.03 GENERAL

A. Fixture Trim: Provide plumbing fixture trim where applicable on fixtures.

B. Plumbing Fixtures: Indicated by fixture number as shown on Drawings.

C. Drainage Products: Indicated by fixture number as shown on Drawings.

D. Plumbing Specialties: Indicated by fixture number as shown on Drawings.

E. Exposed fixture connections and piping shall be polished chrome-plated.

2.04 MATERIALS

A. Fixture Trim:

1. Supply Stop:
   a. Flexible supply with heavy cast brass, loose key, 1/2-inch IPS by 3/8-inch outside diameter tubing angle stop to wall with escutcheon plate; chrome-plated finish.
   b. Provide stop with stuffing box.
   c. Manufacturer: McGuire Manufacturing Company, Inc.
2. Trap:

a. Chrome-plated, 17-gauge, semicast P-trap with compression ring cast brass waste and vent connection and cleanout.
b. 1-1/2 inches for lavatories and drinking fountains.
c. 1-1/2 inches for sinks.
d. Manufacturer: McGuire Manufacturing Company, Inc.

3. Water Closet and Urinal Flush Valves: Sloan Valve Co., Royal Continental, low flush, quiet action with screwdriver stop and vacuum breaker.

B. Plumbing Fixtures:

1. EWC-1, Electric Water Cooler (ADA Compliant, Dual Height):
   a. Finish: No. 4 satin finish stainless steel rectangular receptors, back panel, and grille.
   b. Valve: Front pushbutton operated with automatic stream regulation.
   c. Trim: Screwdriver stop, strainer, and P-trap with cleanout.
   d. Cooler: NonCFC, air-cooled.
   e. Mount: Wall mounting can.
   f. Manufacturer and Product: Haws Drinking Faucet Co.; Model H1119.8.
2. LAV-1, Lavatory (Wall-Hung Type, ADA Compliant):
   a. Fixture: 20 inches by 18 inches, vitreous china, for floor-mounted concealed arm carrier, three-hole punched on 4-inch centers for faucet. American Standard Companies, Inc.; Lucerne, Model 0355.012.
   b. Faucet: Chicago Faucet Co.; Model 2200-4CP with 0.5-gpm flow restricter.
   c. Trim: 3/8-inch supply stop with loose key, 17-gauge chrome-plated cast brass P-trap.
   d. Insulation: McGuire Manufacturing Company, Inc., Prowrap antimicrobial PVC resin seamless insulation for trap, tailpiece, and hot and cold water supply piping.
   e. Strainer: McGuire Manufacturing Company, Inc.; Model 155A chrome-plated grid strainer with tailpiece.
   f. Carrier: Jay R. Smith Mfg. Co.; 700 series concealed arm.
3. MS-1, Mop Sink (Floor Mounted):
   a. Fixture: Stern-Williams Co. Inc.; Model HL-2100-BP; Molded stone, 36 inches by 24 inches by 12 inches deep with stainless steel bumper guard, back panels and chrome-plated brass drain.
   b. Faucet: Chicago Faucet Co.; Model 835-CP, exposed top supplies with hose threads, vacuum breaker, and rod support. Faucet mounted 36 inches above finish floor.

c. Accessories: Stern-Williams Co. Inc.; T-35 hose and T-40 stainless steel mop hanger.

4. SK-1, Sink (Counter, Stainless Steel, Double Compartment):
   a. Fixture: 21 inches by 33 inches overall by 8 inches deep, 18-gauge, Type 304 stainless steel, three-hole punch, self-rimming, undercoated, ledge-type. Just Mfg. Co.; Model DL-2133-A-GR.
   b. Faucet: Chicago Faucet Co.; Model 1201A, double handle.
   c. Trim: 1-1/2-inch outside diameter, 17-gauge chrome-plated cast tailpiece and cast brass P-trap with cleanout, and 1/2-inch wall supply stop with loose key.
   d. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.
5. SH-1, Shower (Stall, ADA Compliant):
   a. Enclosure: Aqua Glass Corp.; Model 833941A, fiberglass enclosure complete with fold-down seat, grab bars, and chrome-plated drain.
   b. Showerhead: Sloan Valve Co.; Model AC-11-B-2.5, with 2.5-gpm flow restricter.
   c. Hand Spray: 2.5-gpm flow restricter, 60-inch flexible stainless steel hose with in-line vacuum breaker, quick disconnect, and 24-inch chrome-plated glide bar.
   d. Mixing Valve: Powers Process Control; Model L425E-1-5-Y-W-QD, thermostatic-type.
   e. Trim: Inlet strainer, check, integral stop, temperature limit stop, two wall hooks, and diverter valve.
6. SH-2, Shower (Trim Only, ADA Compliant):
   a. Showerhead: Sloan Valve Co.; Model AC-11-B-2.5, with 2.5-gpm flow restricter.
   b. Hand Spray: 2.5-gpm flow restricter, 60-inch flexible stainless steel hose with in-line vacuum breaker, quick disconnect, and 24-inch chrome-plated glide bar.
   c. Mixing Valve: Powers Process Control; Model L425E-1-5-Y-W-QD, thermostatic-type.
   d. Trim: Inlet strainer, check, integral stop, temperature limit stop, two wall hooks, and diverter valve.
7. WC-1, Water Closet (Flush Valve, Wall-Hung Type, ADA):
   a. Fixture: Vitreous china, siphon jet action, top spud, elongated bowl. American Standard Companies, Inc.; Afwall EL 1.6, Model 2257.103;
   b. Trim: Sloan Valve Co.; Royal Continental, Model 111 RC; flush valve, 1.6 gallons per flush.
   c. Seat: Olsonite Corp.; 10-CC-SS; white open front.
   d. Carrier: Jay R. Smith Mfg. Co.; Model 200/400, commercial type.

C. Safety Equipment:

1. EE-1, Emergency Eyewash (Deck-Mounted):
   a. Model: Haws Drinking Faucet Co.; Model 7612.
   b. Eyewash: Polished dual chrome-plated brass heads, swing-away design and automatic stream control.
   c. Valve: Stay-open, polished chrome-plated brass ball valve.
2. SSH-1, Safety Shower/Eyewash Combination (Freeze-proof):
   a. Model: Haws Drinking Faucet Co.; Model 8317CTFPT.
   b. Shower: ABS plastic deluge.
   c. Eyewash: Stainless steel bowl with aerated eye/face wash.
   d. Valve: Stay open.
   e. Support: Freestanding, 1-1/4-inch galvanized pipe standard, stanchion, and floor flange, cable heated and insulated.
   f. Alarms: Magnetically operated proximity switches.

D. Drainage Products:

1. CO-1, Cleanout (Exterior):
   a. Material: Taper thread, bronze plug, heavy-duty, scoriated cast-iron top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4263.
2. CO-2, Cleanout:
   a. Material: Taper thread, bronze plug, scoriated nickel bronze top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4023.
3. FCO-1, Floor Cleanout (Finished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured nickel bronze top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4103S.
4. FD-1, Floor Drain (Finished Areas):
   a. Materials: Cast-iron body, adjustable nickel bronze strainer.
   b. Options: Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2005T-U-round.
5. HD-1, Hub Drain:
   a. Coated cast-iron reducing hub adapter with standard cast-iron hub.
   b. Hub: Two pipe sizes larger than outlet.
6. WCO, Wall Cleanout:
   a. Material: Stainless steel cover and screw.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4472.

E. Hose Valves: Refer to Section 22 10 01, Plumbing Piping and Accessories.

F. Plumbing Specialties:

1. Water Hammer Arresters:
   a. Materials: ASSE 1010 certified, Type L copper tube, HHPP piston with two lubricated EPDM O-rings, FDA approved lubricant, rolled piston stop, wrought copper male thread adapter.
   b. Manufacturer and Product: Sioux Chief Mfg. Co., Inc.; Series 650 and 660.
2. TP-1, Trap Priming Valve:
   a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.
   b. Manufacturer and Product: Precision Plumbing Products, Inc.; Model P-1 trap priming valve and Model DU-4, distribution unit.
3. TP-2, Trap Priming Valve:
   a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Figure 2699.
4. ETP-1, Automatic Trap Priming System:
   a. Materials: Electronic controller, manual override switch, solenoid valve, 1/2-inch connection, calibrated water distribution manifold, and air gap.
   b. Power: 120V, single-phase.
   c. Manifold outlet quantity as required.
   d. Manufacturer and Product: Precision Plumbing Products, Inc.; Model MP-500.
5. Pressure/Temperature Relief Valve:
   a. Materials: ASME/AGA rated, bronze body construction, vacuum relief valve vent in drain, backup emergency safety fuse plug, tamper-resistant bonnet screws, test lever, short thermostat, and automatic reseating.
   b. Manufacturer and Product: Watts Industries, Inc.; Series 40.
6. Pressure Gauge:
   a. Materials: 3-1/2-inch gauge size, 0 to 160 psi range, steel case, glass crystal, brass movement, and 1/3-inch NPT lower connection.
   b. Manufacturer and Product: Ashcroft Dresser Instrument Division, Dresser Industries, Inc.; Type 1008.
7. Thermometer:
   a. Materials: Adjustable angle, red reading mercury type with 9-inch case and 30 degrees F to 180 degrees F range, 3-1/2-inch aluminum stem, and separate NPT brass thermowell.
   b. Manufacturer and Product: H.O. Trerice Co.; Model A005.

G. Sealant: In accordance with Section 07 92 00, Joint Sealants.

PART 3 EXECUTION

3.01 PREPARATION

A. Drawings do not attempt to show exact details of fixtures. Changes in locations of fixtures, advisable in opinion of Contractor, shall be submitted to Engineer for review before proceeding with the Work.

3.02 INSTALLATION

A. Fixture Trim: Install fixture trim where applicable on fixtures.

B. Plumbing Fixtures, Mounting Heights:

1. Standard rough-in catalogued heights, unless shown otherwise on Drawings.
2. Caulk fixtures in contact with finished walls with waterproof, white, nonhardening sealant which will not crack, shrink, or change color with age. See Section 07 92 00, Joint Sealants.

C. Exact fixture location and mounting arrangement shall be as indicated on toilet room elevations and details as shown on Drawings.

D. Unless noted otherwise and as a minimum, fixtures shall be supported as indicated in PDI Code Guide 302.

E. Safety Equipment:

1. System Shutoff Valves:
   a. Shutoff valves shall give visual indication of position (open or closed).
   b. Shutoff valves shall be lockable valves and locked in open position.
2. Each safety shower, eyewash, combination safety shower/eyewash shall have red safety signoff tag. After completing requirements listed below, Contractor and Owner shall sign red safety signoff tag. Requirements are as follows:
   a. Visually check safety shower/eyewash piping for leaks.
   b. Verify that upon operation, stay-open valves remain open.
   c. Showerheads to be between 82 inches and 96 inches above standing surface.
   d. Shower spray pattern, when valve is full open, shall be a minimum 20 inches in diameter at 60 inches above standing surface.

e. Water arcs from eyewash spray heads must cross. Test with eyewash gauge; Haws Drinking Faucet Co., Model 9015.
f. Minimum flow rates for safety showers shall be 20 gpm.
g. Minimum flow rates for eyewashes shall be 3 gpm.
h. Tempered water shall be temperature indicated on Drawings.

F. Drainage Products:

1. Floor Drains: Set top flush with floor. Provide membrane clamps where required.
2. Cleanouts: Install where shown or required for purposes intended. Set cover flush with finished floor.
3. Hub Drains: Set top of hub 2 inches above finished floor.

G. Plumbing Specialties:

1. Shock Arresters:
   a. Install PDI-certified and rated shock arresters, sized and located in accordance with PDI WH-201 and as shown on Drawings.
   b. Install adjacent to equipment wherein quick closing valves are installed.
   c. Install at each emergency safety shower.
   d. Shock arresters to have access panels or to be otherwise accessible.
2. Drain P-Trap Priming:
   a. Pipe: Type K, soft copper.
   b. Trap and prime floor drains and hub drains, unless shown otherwise on the Drawings. No attempt has been made to show trap primer valve locations or trap primer pipe routing.
   c. Field route trap primer piping during installation of floor drains and hub drains, and install trap primer valves in mechanical rooms, janitor rooms, or other locations acceptable to Engineer.
   d. Priming System: Complete with connection to serving W1 cold water system.
3. Trap Priming Valves:
   a. Floor drain traps primed with priming valves, 1/2-inch copper to floor drain.
   b. Two traps maximum primed from one priming valve or as recommended by manufacturer. Locate in mechanical spaces or janitor’s rooms and as indicated on Drawings.
   c. Provide shutoff valve ahead of priming valves.
4. Thermometers and Pressure Gauges:
   a. Arrange devices to facilitate use and observation.
   b. Install in orientation that will allow clear observation from ground level.

c. Provide pressure gauges with block valves.
d. Install thermometers in thermowells.

H. Caulk penetrations of exterior walls with weatherproof sealant in accordance with Section 07 92 00, Joint Sealants.

I. Adjust water flows in domestic water systems for reasonable water flows at each plumbing fixture, terminal device, and recirculation loop. Flush valve fixtures shall be adjusted for proper flush cycle time and water quantity.

3.03 FIELD QUALITY CONTROL

A. Perform visual inspection for physical damage, blocked access, cleanliness, and missing items.

B. Notify Owner and Engineer 48 hours prior to shower testing. Owner and Engineer reserve the right to witness all tempered water and safety shower testing.

C. Test safety shower and eyewash units. Water flow must be tested at both showerhead and eyewash/face ring.

1. Shower Flow:
   a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 5-gallon container.
   b. Container shall fill in 10 seconds or less, with a minimum 20-gpm flow.
2. Eyewash Flow:
   a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 1-gallon container.
   b. Container shall fill in 20 seconds or less.
3. Contractor shall log, date, and initial inspection upon passing flow tests.

D. Verify alarm operation both locally and systemwide. Notify security prior to test if alarm is connected systemwide.

END OF SECTION

SECTION 23 05 48
VIBRATION ISOLATION AND SEISMIC CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM):
   a. A36/A36M, Specification for Carbon Structural Steel.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. American Welding Society (AWS): D1.1/D1.1M, Structural Welding Code—Steel.
4. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): Seismic Restraint Manual: Guidelines for Mechanical Systems.
5. Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.02 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. EPDM: Ethylene-Propylene-Diene Monomer.

C. OSHPD: Office of Statewide Health Planning and Development, for the State of California.

D. Withstand: Unit will remain in place without separation of any parts from the device when subjected to seismic forces specified and unit will be fully operational after the seismic event.

1.03 DESIGN REQUIREMENTS

A. Seismic Control:

1. Provide seismic control as required to maintain integrity of mechanical piping, ductwork, and equipment installed in this Project, so they will "withstand" seismic forces.
2. Design shall comply with requirements of this specification.

3. Design, size, and install for piping and equipment throughout facility, whether shown or not.
4. Designed by a registered professional engineer in the state where the Work is to be installed.
5. Design seismic conforming to requirements of SMACNA's Seismic Restraint Manual: Guidelines for Mechanical Systems.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings, Vibration Isolators:
   a. Include, as a minimum, basic equipment layout, length and width, installed operating weights of equipment to be isolated and distribution of weight at isolation points.
   b. Product Data:
      1) Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.
      2) Schedule of vibration isolator type with location and static and dynamic load on each.
2. Shop Drawings, Seismic Control Components:
   a. Include, as a minimum, basic equipment layout, length and width, installed operating weights of equipment to be isolated and distribution of weight at isolation points.
   b. Signed and sealed by a registered professional engineer registered in the state where the Project is located.
   c. Include, as a minimum, a tabulation of design data for each snubber, including specific anchorage details.
   d. Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
   e. Product Data:
      1) Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.
      2) Schedule of seismic control component type with location and static and dynamic load on each.
      3) Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.
   f. Anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
2. Certifications:
   a. Manufacturer's Certificate of Compliance.
   b. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
   c. Welding Certificates: Welding procedures and personnel.
3. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.05 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Isolation materials, flexible connectors, and seismic restraints shall be same manufacturer. Select and certify using published or factory certified data.

C. Vibration isolation and seismic restraint manufacturer shall be a member of the Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

D. Seismic Control:

1. Designer Qualifications:
   a. Professional engineer registered in state where Project resides.
   b. Minimum of 5 years' work experience certifying seismic snubber and anchorage details.
2. Components shall bear anchorage preapproval "R" number, from agency acceptable to AHJ, showing maximum seismic restraint ratings.
3. Horizontal and vertical load testing and analysis shall be performed according to OSHPD requirements.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below which match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Seismic Snubber Units: Furnish replacement neoprene inserts for snubbers.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Article Supplements for product type and capacities.

2.02 VIBRATION ISOLATION

A. General:

1. Provide for mechanical piping, ductwork, and equipment as identified by this Specification.
2. Select in accordance with equipment, pipe, or duct weight distribution to produce reasonably uniform deflections.
3. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 30 percent and 60 percent of maximum deflection.

B. Elastomeric Pad:

1. Oil-resistant and water-resistant elastomer or natural rubber waffle pads, arranged in single or multiple layers, molded with a nonslip pattern.
2. Waffle pads bonded each side of minimum 1/4-inch-thick galvanized steel separator plate.
3. Height of waffle ribs shall not exceed 0.7 times width.
4. Maximum Loading: 60 psi.
5. Minimum Single Layer Thickness: 1/4 inch.
6. Separator plate of sufficient stiffness for uniform loading over pad area.
7. Factory cut to size that matches requirements of supported equipment.
8. Waffle Pad Material: Standard neoprene.
9. Number of Layers: As required to support equipment load; refer to manufacturer’s data for load capacities.

C. Spring Hanger:

1. Combination coil spring and elastomeric insert hanger with spring and insert in compression.
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: 80 percent minimum of compressed height of spring at rated load.
4. Minimum Additional Travel: 50 percent of required deflection at rated load.
5. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element:
   a. Molded, oil-resistant rubber or neoprene.
   b. Steel washer reinforced cup to support spring and bushing projecting through bottom of frame.

D. Manufacturers:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. California Dynamics Corp.
4. Isolation Technology, Inc.
5. M.W. Sausse & Co., Inc. (VIBREX).
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation Co., Inc.
8. The VMC Group.

2.03 FLEXIBLE CONNECTORS

A. Flexible Pipe Connectors:

1. Braided Nonferrous: For nonferrous piping systems, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
2. Braided Stainless Steel: For ferrous piping, provide stainless steel hose covered with Type 304 stainless steel wire braid with NPT steel nipples or 150-psi ANSI flanges, welded to hose.
3. Rubber:
   a. Neoprene or EDPM construction consisting of multiple piles of nylon tire cord fabric and elastomer, molded and cured in hydraulic rubber presses.
   b. Straight or elbow connector as indicated on Drawings, rated at 125 psi at 220 degrees F.
4. Manufacturers:
   1. Mason Industries, Inc.
   2. General Rubber.
   3. Kinetics Noise Control, Inc.

B. Flexible Duct Connectors: Refer to Section 23 31 13, Metal Ducts and Accessories.

2.04 SEISMIC RESTRAINTS

A. Resilient Isolation Washers and Bushings: One-piece, molded neoprene, having a durometer 60, plus or minus 5, with a flat washer face.

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

C. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.

D. Anchor Bolts:

1. Seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

E. Manufacturers:

1. California Dynamics Corp.
2. Kinetics Noise Control, Inc.
3. Loos & Co., Inc.; Cableware Technology Division.
4. Mason Industries, Inc.
5. M.W. Sausse & Co., Inc. (VIBREX).
6. TOLCO Incorporated.
7. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
8. Vibration Eliminator Co., Inc.
9. Vibration Isolation Co., Inc.
10. The VMC Group.

2.05 SHOP/FACTORY FINISHING

A. Manufacturer’s standard paint applied to factory-assembled and factory-tested equipment, before shipping.

1. Powder coating on springs and housings.
2. Electro-galvanized hardware.
3. Hot-dip galvanized metal components for exterior use.
4. Baked enamel coat metal components for interior use.

B. Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.

PART 3 EXECUTION

3.01 EXAMINATION

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

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

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

3.02 INSTALLATION

A. General:

1. Install products in accordance with manufacturers' written instructions.
2. Connect wiring to isolated equipment with flexible hanging loop.
3. Install roof curbs, equipment supports, and roof penetrations as specified in Section 07 70 01, Roof Specialties and Accessories.
4. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.
5. Locate isolation hangers as near overhead support structure as possible.

B. Vibration Isolators:

1. Install spring hangers without binding.
2. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

C. Flexible Connectors:

1. Install at pumps, chillers, air handling units, hydronic coils, equipment on or with vibration isolation, and at building seismic joints.
2. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

D. Seismic Restraint Devices:

1. Notify local representative of seismic restraint materials manufacturer prior to installing seismic restraint devices.

2. No rigid connections between equipment and building structure shall be made which degrades seismic restraint system herein specified.
3. Electrical conduit to restrained equipment shall be looped to allow free motion of equipment without damage to electrical wiring.
4. Install seismic snubbers on isolated equipment.
5. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
6. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
7. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers.
8. At trapeze anchor locations, shackle piping and equipment to trapeze.
9. Install resilient bolt isolation washers on equipment anchor bolts.
10. Upon completion of seismic restraint material installation and before startup of restrained equipment, clean debris from beneath protected equipment, leaving equipment free to contact snubbers.

3.03 FIELD QUALITY CONTROL

A. Testing:

1. Conduct the following field quality control testing:
   a. Isolator deflection.
   b. Isolator seismic restraint clearance.
   c. Snubber minimum clearances.

B. Seismic Control Component Inspection:

1. Conduct periodic inspections of material installation with assistance of manufacturer’s representative. Report in writing deviations from good installation practice.
2. Upon completion of seismic restraint device installation inspect completed system with assistance of manufacturer’s representative. Report in writing installation errors, improperly selected snubber devices, or other fault in the system that could affect performance of the system.

3.04 MANUFACTURER'S SERVICES:

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional and] performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.05 ADJUSTING

A. Vibration Isolation Devices:

1. Adjust isolators after piping systems have been filled and equipment is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height.
3. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
4. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.
5. Adjust isolators to ensure units do not exceed rated operating deflections or bottom out under loading, and are not short circuited by other contacts or bearing points.
6. Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

B. Seismic Control Components:

1. Adjust snubbers according to manufacturer's written recommendations.
2. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.
3. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.06 CLEANING

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

3.07 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Section 23 05 48.01, Vibration Isolation Schedule for HVAC Piping and Equipment.

END OF SECTION

VIBRATION ISOLATION SCHEDULE FOR HVAC PIPING AND EQUIPMENT 23 05 48.01

ISOLATED EQUIPMENT	DESCRIPTION		OUTDOOR AIR CONDENSER UNITS	FAN, INLINE CENTRIFUGAL	DUCT HEATER		
	TAG NUMBERS		ALL	050-EF-2,3,5 & 6	050-GDH-1		
	LOCATION		GROUND	SUSPENDED	SUSPENDED		
VIBRATION ISOLATOR	TYPE		ELASTOMERIC PAD	SPRING HANGER	SPRING HANGER		
	MINIMUM DEFLECTION	INCH	0.25	0.25	0.25		
EQUIPMENT BASE	TYPE		NONE	NONE	NONE		
FLEXIBLE CONNECTOR	TYPE		FLEX PIPE CONN - BRAIDED NON-FERROUS	FLEXIBLE DUCT CONNECTOR - VINYL	FLEXIBLE DUCT CONNECTOR - SILICONE		
	MINIMUM DEFLECTION	INCH	2	3	3		
ISOLATED EQUIPMENT	DESCRIPTION						
	TAG NUMBERS						
	LOCATION						
VIBRATION ISOLATOR	TYPE						
	MINIMUM DEFLECTION	INCH					
EQUIPMENT BASE	TYPE						
FLEXIBLE CONNECTOR	TYPE						
	MINIMUM DEFLECTION	INCH					

REMARKS:

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

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
3. Associated Air Balance Council (AABC): National Standards for Field Management and Instrumentation Total System Balance.
4. National Environmental Balancing Bureau (NEBB):
   a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
   b. Procedural Standards for Measuring Sound and Vibration.
5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.02 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.
2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.
3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
4. Written verification of calibration of testing and balancing equipment.
5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.03 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.
3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.

4. Have a proven record of at least five similar projects.
5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

C. Drives for Belt-Driven Fans:

1. Furnish cast iron or flanged steel sheaves.
2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.
B. Adjust and balance heating system during the coldest month and cooling systems during the hottest month respectively.

3.02 ADJUSTING AND BALANCING AIR SIDE

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
   a. Review shop drawings and installed system for adequate and accessible balancing devices and test points.
   b. Recommend to Engineer dampers that need to be added or replaced in order to obtain proper air control.
   c. Verify proper startup procedures have been completed on the system
   d. Verify controls installation is complete and system is in stable operation under automatic control.
   e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer’s recommended calibration interval before beginning the Work.

B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.

C. Equipment Data:

1. Collect the following data and included in final report:
   a. Type of unit.
   b. Equipment identification number.
   c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
   d. Motor data (frame, hp, volts, FLA rpm, and service factor).
   e. Sheave manufacturer, size, and bore.
   f. Belt size and number.
   g. Sheave centerline distance and adjustment limits.
   h. Starter and motor overload protection data.
   i. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
   a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 5 percent minus 0 percent.
   b. After final adjustments, do not operate motor above nameplate amperage on any phase.
   c. After final adjustments, do not operate fan above maximum rated speed.
   d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
   e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Engineer if drive or belt changes were made.

4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

1. In each system at least one air path from fan to final branch duct termination shall have dampers fully open.
2. Adjust air volumes on supply diffusers and grilles, and on return and exhaust grilles, to the quantity shown, with allowable variation of plus or minus 5 percent.
3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.

F. Building Static Pressure:

1. Measure building static pressure relative to outside in perimeter entrances during normal system conditions that would yield widest range in internal building pressure.
2. Adjust building static pressure control parameters to ensure perimeter entrances are positive or negative as shown in drawings airflow diagrams to outdoors by 0.05-inch WC with entrance doors closed.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01 91 14, Equipment Testing and Facility Startup.

B. Performance Testing:

1. Heating Coil or furnace Testing:
   a. Adjust system as required to achieve full output from coil.
   b. Read and record amperages and voltages for all phases.
2. Heating or Sensible Cooling Coil Testing:
   a. Adjust system as required to achieve design flow conditions for air sides of coil.
   b. Measure and record airflow rate, entering air temperature, leaving air temperature.

3. Cooling or Dehumidification Coil Testing:
    a. Adjust system as required to achieve design flow conditions for coil.
    b. Measure and record airflow rate, entering air dry bulb and wet bulb temperatures, leaving air dry bulb and wet bulb temperatures.
    c. Test Procedures:
        1) Identify maximum vibration velocity limits as specified for each piece of equipment to be tested.
        2) Take measurements at each bearing housing using calibrated electronic analyzer.
        3) Measure velocity in direction parallel to rotating shaft, and in two directions perpendicular to shaft and to each other. Align measurement directions where possible to the horizontal and vertical planes.
        4) Record log shall include equipment symbol or tag, location, identification, specified vibration velocity limits, and maximum measured velocity in each direction.
        5) Notify Engineer if amplitude exceeds upper limit specified.

C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
    a. Air balancing procedures, vibration tests, and verification of test results.

b. Perform spot tests on a maximum of 50 percent of total diffusers and grilles, on two air handling fan devices per building, with measuring equipment used in original tests, at random points selected by Engineer.
c. Results of these spot tests shall agree with balance logs within plus or minus 5 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Engineer.
d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. Association of the Nonwoven Fabric Industry (INDA). IST 80.6, Water Resistance (Hydrostatic Pressure).
3. ASTM International (ASTM):
    a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    b. C547, Standard Specification for Mineral Fiber Pipe Insulation.
    c. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
    d. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
    e. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
    f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    g. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
    h. G22, Standard Practice for Determining Resistance of Plastics to Bacteria.
4. National Fire Protection Association (NFPA):
    a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
    b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
    c. 259, Standard Test Method for Potential Heat of Building Materials.
5. UL.

1.02 DEFINITIONS

A. Cold Air Ductwork: Designed to convey mechanically cooled air or return ducts in such systems.

B. Warm Air Ductwork: Designed to convey mechanically heated air or return ducts in such systems.

1.03 SUBMITTALS

A. Action Submittals: Product description, list of materials and thickness for each service or equipment scheduled, locations, and manufacturer's installation instructions.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Operation and maintenance data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Materials furnished under this specification shall be standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

C. UL listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Every package or standard container of insulation, jackets, cements, adhesives and coatings delivered to Project Site for use must have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation Packages and Containers: Marked "asbestos-free."

PART 2 PRODUCTS

2.01 GENERAL

A. Insulation Exterior: Cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Insulation: Conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for Fittings, Flanges, and Valves: Premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Insulation, Adhesives, Vapor Barrier Materials and Other Accessories, Except as Specified Herein: Noncombustible.
2. Do not use fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration resulting from the effects of moisture or high humidity are not acceptable.
4. Provide materials including facings, mastics, and adhesives, with fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with ASTM E84 (NFPA 255) methods.

E. Materials exempt from fire-resistant rating:

1. Nylon anchors.
2. Treated wood inserts.

F. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:

1. Polyurethane insulation.
2. PVC casing.
3. Fiberglass-reinforced plastic casing.

2.02 PIPE INSULATION

A. Type P3—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water vapor transmission 0.1 perm-inch, or less.

4. Manufacturers and Products:
    a. Armacell; AP Armaflex.
    b. Nomaco; K-Flex LS.

2.03 DUCT INSULATION

A. Type D1—Blanket (ASTM C553, Type 1, Class B3):

1. Fiberglass, nominal 1 pcf density blanket, K factor 0.31 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures to 250 degrees F.
2. Manufacturers and Products:
    a. CertainTeed; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Owens/Corning Fiberglass; Soft R.
    d. Knauf; Ductwrap.

B. Type D2—Board:

1. Fiberglass, minimum 2.75 pcf density board, K factor 0.23 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures from 0 degree F to 450 degrees F.
2. Manufacturers and Products:
    a. CertainTeed; CertaPro Commercial Board.
    b. Knauf; Duct Slab.
    c. Owens/Corning Fiberglass; TIW.
    d. Johns Manville; 1000 Series Spin-Glass.

C. Type D3—Liner (ASTM C1071, Type 1):

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean, black composite coated surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
2. Liquid water repellency rating not less than 4 when tested in accordance with INDA IST 80.6.
3. Potential heat value not exceeding 3,500 Btu/lb when tested in accordance with NFPA 259 and meeting the classification of “Limited Combustible” as defined by NFPA 90A.
4. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
5. Resistant to microbial growth using a “no growth criteria” when tested in accordance with ASTM C1139, ASTM G21, and ASTM G22.
6. Manufacturers and Products:
    a. CertainTeed; Toughgard.
    b. Johns Manville; Linacoustic (rectangular), Spinacoustic (Round).
    c. Knauf; Acoustic Duct Liner.

2.04 INSULATION FINISH SYSTEMS

A. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturer and Product: Armstrong; WB Armaflex finish.

B. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100 or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. Moisture Barrier: Provide factory applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturer and Product:
   a. RPR Products; INSUL-MATE.
   b. ITW, Pabco-Childers.

PART 3 EXECUTION

3.01 APPLICATION OF PIPING INSULATION

A. Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal all butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

K. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

L. Insulate valve bodies, flanges, and pipe couplings.

M. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

N. Do not insulate flexible pipe couplings and expansion joints.

O. Do not allow insulation to cover nameplates or code inspection stamps.

P. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

Q. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

R. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

S. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

T. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

U. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF DUCTWORK INSULATION

A. General: Install insulation products in accordance with the manufacturer's written instructions and in accordance with recognized industry practices.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulation. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation and protect it to prevent puncture and other damage. Tape all punctures.

E. Seal longitudinal and circumferential joints with FSK tape, and finish with fiberglass mesh fabric embedded in vapor barrier mastic.

F. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

G. Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

H. Refer to Section 23 31 13, Metal Ducts and Accessories, for installation of internal duct liner.

3.03 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal all exterior joints to make watertight.

3.04 PIPING INSULATION REQUIREMENTS

A. Refrigeration Suction:

1. Type P3, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 1 inch.
3. 3/4-inch thickness for pipe sizes over 1 inch.

B. Condensate Drain:

1. Type P3, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 2-5/8 inches ID.
3. 3/4-inch thickness for pipe sizes over 2-5/8 inches ID.

C. Pipe Hangers:

1. Type P3, Elastomeric: Rigid insulation section with 9-inch-long, 16-gauge galvanized steel saddle.

3.05 DUCTWORK INSULATION REQUIREMENTS

A. Mechanically Cooled and Heated Supply and Return Air; (Concealed):

1. Type D1, blanket.
2. 2-inch thickness.

B. Mechanically Cooled and Heated Supply and Return Air, and Outside Air (Exposed to View):

1. Type D2, board.
2. 1-1/2-inch thickness.

C. Outdoor supply ductwork:

1. Double wall ductwork, Type D3, liner.
2. 1-1/2-inch thickness.

D. Sheet Metal Plenums:

1. Type D3, liner.
2. 1-1/2-inch thickness.

E. Transfer Air:

1. Type D3, liner.
2. 1/2-inch thickness.

F. Air Distribution Devices: Refer to Section 23 37 00, Air Outlets and Inlets, for requirements.

3.06 INSULATION FINISH REQUIREMENTS

A. Piping, Duct, and Equipment Insulation (Concealed Areas): Factory finish.

B. Piping Insulation (Exposed to View, Indoors): Type F3, aluminum.

C. Ductwork Insulation (Exposed to View, Indoors): Factory finish.

D. Piping Insulation (Outdoors): Type F3, aluminum.

E. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.07 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

END OF SECTION

SECTION 23 09 00
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): INCITS 4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   a. Handbook Fundamentals.
   b. Guideline 3, Reducing Emission of Fully Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
   c. 135, Data Communication Protocol for Building Automation and Control Networks.
3. American Society of Mechanical Engineers (ASME): B19.3, Safety Standard for Compressors for Process Industries.
4. American Water Works Association (AWWA): C704, Propeller-Type Meters for Waterworks Applications.
5. Electronic Industries Alliance (EIA):
   a. TIA-232-F, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485, Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
6. Federal Communications Commission (FCC).
7. International Organization for Standardization (ISO): 8802-3, Information Technology - Telecommunication and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Carrier Sense Multiple Access with Detection (CSMA/CD) Access Method and Physical Layer Specifications.
8. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
10. Underwriters Laboratories, Inc. (UL): 916, Standard for Safety Energy Management Equipment.

1.02 DEFINITIONS

A. The terms “HVAC Control System,” “Automatic Temperature Control System,” “Building Automation System,” and “Environmental Management and Control System” shall be considered equivalent and used interchangeably for the purposes of this Contract.

B. Algorithm: A software procedure for solving a recurrent mathematical or logical problem.

C. Analog: A continuously varying signal or value (temperature, current, velocity, etc.).

D. Binary: A two-state system where an “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.

E. Control Wiring:

1. Wiring, high or low voltage other than power wiring required for proper operation of mechanical systems.
2. Includes conduit, wire and wiring devices to install complete control system including motor control circuits, interlocks, thermostats and.
3. Includes wiring from DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute sequence of operation.
4. Includes necessary power wiring to HVAC control devices, digital controllers including terminal units and actuators.

F. Control Process: Software required to complete control loop from input signal to interlock logic and process calculation to final output signal control.

G. Deadband: Temperature range over which no heating or cooling energy is supplied, such as 72 degrees F to 78 degrees F; as opposed to single point changeover or overlap, or a range from set point over which no control action is taken.

H. Direct Digital Control (DDC): Consists of microprocessor-based controllers with control logic performed by software. Analog-to-digital (A/D) converters transform analog values into digital signals that microprocessor can use.

I. Power Wiring: Line voltage wiring to mechanical equipment. Line voltage wiring that also serves as control circuit, such as line voltage thermostat or involves interlocking with damper shall be considered control wiring.

J. Abbreviations that may be used in this section:

1. AC: Air Conditioning.
2. ATC: Automatic Temperature Control.
3. DDC: Direct Digital Control.
4. DX: Direct Expansion.
5. HCP: HVAC Control Panel.
6. HOA: Hand-Off-Auto (Switch).
7. HVAC: Heating, Ventilation, and Air Conditioning.
8. IP: Current (I) - Pressure (P), as in IP transducer.
9. LCD: Liquid Crystal Display.
10. LED: Light Emitting Diode.
11. RAM: Random Access Memory.
12. RTD: Resistance Temperature Detectors.
13. VAV: Variable Air Volume.

1.03 SYSTEM DESCRIPTION

A. General Requirements:

1. Power wiring and associated conduit shall be provided by electrical contractor. Control wiring and associated conduit shall be provided by HVAC contractor unless coordinated with the electrical contractor.
2. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
3. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
4. Provide controls necessary for entire system to have fail-safe operation.
5. Control sequences and functions including alarms, monitoring and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation.
6. Provide sequences and functions as required to deliver a fully functioning HVAC system.

B. Control System Types:

1. The following control system types may be used in this Project:
   a. Electric/Electronic Control System (ELECTRIC/ELECTRONIC):
      1) System using simple electric or electronic control devices.
      2) User interface at control device.

b. Standalone DDC Control System (STANDALONE DDC).
   1) Provided by equipment manufacturer as integrated part of the HVAC equipment. No separate DDC spec is provided in this project.
   2) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
   3) No information sharing between controllers.
   4) User interface at DDC controller.

2. Provide control system(s) of architecture defined in Control Type Schedule, below:

Control Type Schedule		
Location	**System**	**Control Type**
All	Where operating sequences call for simple thermostatic or interlock control	ELECTRIC/ELECTRONIC
Integrated with equipment provided by equipment manufacturer.	Where operating sequences call for DDC control	STANDALONE DDC

C. Performance Requirements: Design control system and equipment to perform under the following conditions:

1. Temperature, Ambient:
   a. Summer maximum 94.6 DB/74.8WB degrees F.
   b. Winter minimum 15.4 DB degrees F.
   c. Based on ASHRAE Handbook Fundamentals weather data for the near City of Nashville, TN.
2. Temperature, Indoor:
   a. Heated and Ventilated Process Areas: Summer maximum 104 degrees F; winter minimum 50 degrees F.
   b. Air-conditioned Nonprocess Areas: Summer maximum 75 degrees F; Winter minimum 70 degrees F.
   c. Laboratory: Summer maximum 72 degrees F; winter minimum 72 degrees F.
   d. Electrical room: Summer maximum 77 degrees F; Winter minimum 50 degrees F.

1.04 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that includes make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
3. Complete drawings and schematics of proposed control system, including panel power requirements.
4. System operating sequences to be programmed, in exact English language.
5. Complete points list.
6. Interfaces with HVAC equipment.
    a. Schematic diagram of each equipment item.
    b. Indicate location of each control item in equipment.
    c. Show equipment manufacturer controls where installed.
7. Panel face layout drawings.
8. Damper actuator sizing calculations, in schedule form.

B. Informational Submittals:

1. Table identifying which member of Contractor's team is responsible for furnishing and setting in-place power wiring and control wiring of each item or component of HVAC equipment.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer's Certificate of Compliance.
4. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
5. Confirmation that control system Supplier has received and coordinated with all approved HVAC equipment submittals.
6. Experience and qualifications of control system Supplier's proposed representative who will supervise installation, adjustment, and calibration of control systems.
7. Performance test plan and schedule.
8. Test Results:
    a. Functional and performance test documentation.
    b. Component calibration sheets for each instrument and panel component as described in Section 40 90 00, Process Instrumentation and Control Systems.

9. Operation and maintenance data: In accordance with Section 01 78 23, Operation and Maintenance Data. In addition, include the following detailed information:
    a. Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
    b. Record of system adjustments and calibration methods.
    c. Performance test results.

1.05 QUALITY ASSURANCE

A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (UL).

B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.

1. Underwriters Laboratories: Products shall be UL 916-PAZX listed.
2. National Electrical Code NFPA 70.
3. Federal Communications Commission Part J.

C. Qualifications of HVAC Controls System Supplier:

1. Minimum of 15 years' experience in design, installation, and maintenance of fully electronic building automation systems.
2. Minimum of 10 years' experience in design, installation, and maintenance of computer based, direct digital control, facility automation systems.
3. Minimum of 5 years' experience as manufacturer's authorized representative in design, installation, and maintenance of manufacturer's system and products.
4. Capable of furnishing factory-trained technicians, competent to provide instruction, routine maintenance, and emergency service onsite within 4 hours after receipt of request.
5. Factory trained certified engineering and commissioning staff, and complete offsite training facilities.
6. Necessary facilities to provide Owner with complete maintenance, periodic inspection, and service contract. Refer to Paragraph, Maintenance.

D. FCC Regulation: Electronic equipment shall conform to requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

E. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years. Future compatibility shall be supported for no less than 10 years.
2. Compatibility shall be defined as:
   a. Ability to upgrade existing field panels to current level of technology, and extend new field panels on previously installed network.
   b. Ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Corrosion Protection:

1. Control panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, shall be protected from corrosion through use of corrosion-inhibiting vapor capsules.
2. Prior to shipment, capsules shall be provided within shipping containers and equipment as recommended by capsule manufacturer.
3. During construction period, capsules shall be replaced in accordance with capsule manufacturer's recommendations.

1.07 EXTRA MATERIALS

A. Tools:

1. For each building, furnish one complete set of special tools recommended by manufacturer for maintenance, dismantling, or repair of each separate type of equipment item.
2. Furnish toolbox for storage of special tools. Identify purpose by means of stainless steel or solid plastic nametag attached to box.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified shall be products of the following manufacturers, unless indicated otherwise:

1. Allen Bradley.
2. Siemens Building Technologies.
3. Johnson Controls.

4. The Trane Company.
5. Honeywell.
6. Invensys.
7. Alerton Technologies.
8. Delta Controls.
9. Automated Logic Corporation.
10. Andover.

2.02 MATERIALS

A. General:

1. Products used in this installation shall be new, currently under manufacture, and shall have been applied in similar installations for minimum of 2 years.
2. System shall not be used as test Site for new products, unless explicitly approved by Owner's representative, in writing.

B. Control Components:

1. Control range to obtain specified capacities.
2. Sensitivity to maintain control points close enough to set point for acceptable offset, without cycling equipment more frequently than recommended by manufacturer.
3. Field or computer adjustable to actual set point, ranges. Adjustable to other settings that will provide proper operation of entire control system.

C. Controls Interfacing:

1. Interface controls properly with factory supplied components of mechanical systems. Coordinate special control interfacing requirements.
2. For equipment that requires special interfacing with control system, provide equipment with integral controls or provide accessory devices required for operation of total mechanical system.
3. Coordinate interfaces with electrical work as necessary.
4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.03 LABELING

A. All products, namely electrical materials, devices, appliances, and equipment used, shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (UL) and Factory Mutual (FM).

B. Valid label affixed to item shall provide indication of product acceptance by required agencies.

C. HVAC control panels and control components that consist of multiple components shall bear UL listing mark on unit.

2.04 SERVICE CONDITIONS

A. Refer to Electrical Drawings for classification of areas as hazardous, corrosive, wet, indoor dry, and dust-tight.

B. Use materials and methods, and enclose devices in NEMA enclosure types suitable for classification indicated, and as required by NFPA 70.

C. Exhaust ductwork shall be considered same classification as area served.

D. Instruments within 3 feet of ducts conveying air from spaces classified as Class I, Division 1 or Division 2 (in accordance with NFPA 70) shall be suitable for same area classification as space exhausted.

2.05 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Electrical components shall be provided in accordance with requirements of Division 26, Electrical.

B. Wiring:

1. In accordance with Section 26 05 05, Conductors, and NFPA 70.
2. Insulation shall be rated 600 volts, minimum.

C. Electrical Raceways: In accordance with Section 26 05 33, Raceway and Boxes, and NFPA 70.

D. Provide surge suppressors on each power connection, meeting applicable requirements of Section 40 90 00, Instrumentation and Control for Process Systems.

2.06 FIELD COMPONENTS AND INSTRUMENTS

A. Refer to HVAC controls detailed specification, Section 23 09 13, HVAC Controls, Field Components, and Instruments.

2.07 ACCESSORIES

A. Corrosion-inhibiting vapor capsules as manufactured by:

1. Northern Instruments; Model Zerust VC.
2. Hoffman; Model A-HCI.

B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

C. Equipment Identification Plates:

1. Provide 16-gauge 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8 inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.
2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
    a. Night low limit thermostats.
    b. Manual override timers.
    c. Switches.
    d. Humidistats.
    e. Emergency STOP switches.
    f. Special purpose devices.
    g. HVAC control panels.

D. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

2.08 EQUIPMENT FINISH

A. Provide materials and equipment with manufacturer’s standard finish system. Provide manufacturer’s standard finish color, except where specific color is indicated.

B. If manufacturer has no standard color, provide gray finish as approved by Engineer.

PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference Contract Drawings.

3.02 INSTALLATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
2. Changes in location or installation of control devices or equipment shall be approved by Engineer before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.
4. Protect control equipment located in areas identified as being corrosive as follows:
    a. Use corrosion-inhibiting vapor capsules inside control equipment enclosures and HCP.
    b. Replace capsules prior to Owner's acceptance of equipment.

B. Wiring:

1. General:
    a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
    b. Install control and interlock wiring separate from power wiring.
    c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.
    d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.
    e. Restrain wiring in control panels by plastic ties or ducts.
    f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
    g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
    h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.

i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
j. Properly support and run wiring in a neat manner.
k. Run wiring parallel or at right angles to building structure.

2. Concealment:
   a. Generally conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
   b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit, in accordance with Division 26, Electrical.
   c. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
   d. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

C. End-User Accessible Control Components:

1. Do not mark room thermostats.
2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

D. Control Dampers:

1. Verify correctness of installation.
2. Verify proper control action.
3. Adjust limit switch settings.
4. Adjust opening and closing speeds, and travel stops.
5. Stroke control dampers by means of associated control output.

E. HVAC Control Panel (HCP) Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.
3. Field termination wiring shall have designated instrument tag.
4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.

8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (such as, terminal blocks, power supplies, relays).

3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing:

1. Tests and certification shall be as specified in Section 01 91 14, Equipment Testing and Facility Startup, and Section 01 43 33, Manufacturers' Field Services.
2. HVAC controls interface with process control system shall be coordinated with the Work of Section 40 90 00, Instrumentation and Control for Process Systems.

3.04 MANUFACTURER'S SERVICES

1. Provide manufacturer's services in conformance with requirements of Section 01 43 33, Manufacturers' Field Services.
2. Manufacturer's Representative: Present at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation, assistance, and inspection.
   b. 1 person-day for functional and performance testing and Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for facility startup.
   d. 1 person-day for post-startup training.

3.05 TRAINING

A. Provide training of Owner's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.

B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.

3.06 ADJUSTING AND CALIBRATING

A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.

B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.

C. Adjustment Record:

1. Prepare complete record of system adjustments for each control system.
2. Indicate deviations from specified temperatures.
3. Include copy of completed record in each copy of Operation and Maintenance Manual.

3.07 CLEANING AND TOUCHUP PAINTING

A. Touchup scratches, scrapes, or chips in exterior surfaces with finish matching type, color, consistency, and type of surface of original finish.

END OF SECTION

SECTION 23 09 13
HVAC CONTROLS, FIELD COMPONENTS, AND INSTRUMENTS

PART 1 GENERAL

1.01 GENERAL

A. This section is a supplement to Section 23 09 00, Instrumentation and Control Devices for HVAC.

B. The requirements of this section shall be provided in addition to those listed in Section 23 09 00, Instrumentation and Control Devices for HVAC.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 EXTRA MATERIALS

A. HVAC Control Panel (HCP) Spare Lamps: Furnish spare lamps for each type and color of pilot light used, a minimum of one per HCP, stored inside HCP in dummy light sockets secured to back panel surface.

PART 2 PRODUCTS

2.01 HVAC CONTROL PANELS (HCP)

A. Provide at locations shown on Drawings for convenient operator interface with control system.

B. A single 120-volt, 20-amp feeder shall serve each HCP, unless otherwise indicated.

C. HCP Contents: Electronic indication relays, control switches, transformers, pilot lights, alarm lights, and other devices necessary for particular system.

D. HCP Construction:

1. Construct each HCP to NEMA 250 rating as indicated in Schedule below**,** except where indicated otherwise:

HVAC Control Panel (HCP) NEMA 250 Construction Schedule

Location	NEMA 250 Type
RAS/WAS Pump Station (030-HCP-01)	4X

2. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
3. Hinged front door with locking handle.
4. Flush-mount manual switches, pilot lights, and direct-reading gauges on front panel face.
5. Identify front panel mounted devices and HCP with labeling in accordance with Section 23 09 00, Instrumentation and Control Devices for HVAC.

E. Panel Listing: Panels shall bear UL or ETL listing mark stating “LISTED ENCLOSED INDUSTRIAL CONTROL PANEL.”

F. Control Devices:

1. Mount inside HCP.
2. Prewired internally.
3. Terminate wires leaving HCP at separately numbered terminal strips (one terminal pair per circuit).
4. Furnish individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.
5. Refer to Drawings for power and control circuit requirements.
6. Identify wires by color coding or numerical tags at both ends.
7. Wire control devices without splices to the terminal strip.
8. Furnish integral circuit protection for panel mounted control devices.
9. Acknowledge and Reset buttons for the associated ventilation monitoring system. See panel face design in drawings. The buttons shall be a momentary pushbutton switch, is corrosion resistant, suitable for wall mounting and is rated at 120V ac, 60 Hz, three amperes. The test button shall be an Allen-Bradley Company Bulletin 800H, heavy duty pushbuttons factory assembled station or equal.

G. Terminal Blocks:

1. One-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts.
2. Double sided and supplied with removable covers to prevent accidental contact with live circuits.
3. Furnish permanent, legible identification, clearly visible with protective cover removed.
4. Terminate wires at terminal blocks with crimp type, preinsulated, ring-tongue lugs.
5. Size lugs for terminal block screws and for the number and size of wires terminated.
6. Provide screwdriver access for blade width of a minimum of 3/16 inch or Klein 601 Series screwdrivers. Terminals requiring use of special screwdrivers are not acceptable.

H. Miscellaneous Accessories:

1. Furnish panel as-built electrical wiring schematics, secured to inside of panel door, or enclosed in plastic jackets placed inside each panel.
2. Install plastic or stick-on labels on interior control devices to identify them in conjunction with control schematics.

2.02 VENTILATION MONITORING STATION (030-VMS-01)

A. Signaling notification alarm panels shall be installed where shown on the drawings and interlocked with the HVAC control panel 030-HCP-01 to provide ventilation system status and alarm.

B. Each Panel shall include the following.

1. Green indicating status light with “VENTILATION SYSTEM ACTIVE” sign.
2. Red indicating status light with “WARNING – VENTILATION SYSTEM FAIL” sign.
3. Horn with test push button.

C. Stations shall be wall mounted with Type 316 stainless steel hardware. Mounting fittings shall be provided by the manufacturer.

D. VMS Indicating lights:

1. General: Green and Red indicating lights shall provide a visual indication of the ventilation system status.

2. Required Features:
    a. LED Light: Steady-burn; 60,000 hours
    b. Lens Color: Red and Green as indicated.
    c. Enclosure: NEMA 4X.
    d. Power: Feed from 030-HCP-01.
    e. Approvals: UL Listed for Class 1, Div 1, Groups C & D.
    f. Dimensions: 15.63-inch high and 8.82-inch diameter.
    g. Dome guard.
    h. 90 degrees wall mounted bracket.
3. Manufacturer: Provide one of the following:
    a. Federal Signal Corporation.
    b. Larson Electronics, LLC.
    c. Or “Equal”.

E. VMS Horn:

1. General:
    a. Function: Audible alarm suitable for use in a hazardous location and also indoor/outdoor use.
2. Performance:
    a. Temperature, Operating: Minus 54 degrees C to 66 degrees C.
3. Features and ratings:
    a. Hazardous Location: Class I, Div 2, Groups A, B, C, D.
    b. Dimensions: 4.4 inches in height and width, and 4.0 inches in depth, nominal.
    c. Speaker Cone: Polymeric.
    d. Listings: UL, cUL listed, FM, CSA approved.
4. Enclosure:
    a. Type: Non-metallic polycarbonate light gray.
    b. Rating: NEMA 4X.
    c. Mounting: Surface mount.
5. Power: 120V ac.
6. Manufacturer:
    a. Federal Signal Corporation.
    b. Or “Equal”.

F. VMS Test button: A test button shall be conveniently located in each VMS for the purpose of activating the audible and visual signals in order to validate their operation. The test button shall be a momentary pushbutton switch, is corrosion resistant, suitable for wall mounting and is rated at 120V ac, 60 Hz, three amperes. The test button shall be an Allen-Bradley Company Bulletin 800H, heavy duty pushbuttons factory assembled station or equal.

2.03 STROBE WARNING LIGHTS

A. Strobe warning lights shall be installed where shown on Drawings and interlocked with panel 26-HCP-1 to provide ventilation system status and alarm. The strobe warning lights shall be loop powered.

B. General:

1. Function: Warning light.
2. Type:
   a. Flashing LED.
   b. Suitable for hazardous locations.
3. Operating Temperature: minus 58 to 150 degrees F.
4. Performance:
   a. Flash Rate: 60 per minute.
5. Features:
   a. Flashing, super bright LED array.
   b. Lamp Life: 60,000 hours.
   c. Construction:
      1) Aluminum Powder-coated base.
      2) Glass dome with Gasket
   d. Dome guard.
   e. Dome Color: Red, unless otherwise noted.
   f. Mounting: Pipe, unless otherwise noted.
   g. Enclosure Rating: NEMA 4X.
   h. Light Diameter: 6-inches nominal.
6. Hazardous Approvals: Class I, Division 2, Groups A, B, C and D.
7. Manufacturer:
   a. Federal Signal Corporation.
   b. Or “Equal”.

2.04 CONTROL DAMPERS

A. General:

1. Specification applies to control dampers, except those specified to be furnished with equipment.
2. Furnish opposed-blade type for proportional action and parallel-blade type for two-position action, except where indicated otherwise.

B. High Performance Control Dampers (MD):

1. Frame: Frame: 5 inches by 1 inch by minimum 0.125 inch (127 mm by 25 mm by minimum 3.2 mm) 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.

2. Blades:
    a. Style: Airfoil-shaped, single-piece.
    b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
    c. Material: Heavy duty 6063-T5 extruded aluminum.
    d. Width: Nominal 6 inches (152 mm).
3. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
4. Seals:
    a. Blade Seals: As scheduled on Drawings.
    b. Jamb Seals: As scheduled on Drawings.
5. Linkage: Concealed in frame.
6. Axles:
    a. Minimum 1/2 inch (13 mm) diameter, hex-shaped, mechanically attached to blade.
    b. Material: As scheduled on Drawings.
7. Performance Data: As scheduled on Drawings.
8. Accessories: As scheduled on Drawings.
9. Manufacturers:
    a. Ruskin.
    b. American Warming and Ventilating.
    c. TAMCO.
    d. Greenheck.

C. Heavy Duty Control Dampers (MD):

1. Frame:
    a. 8 inches by 2 inches by minimum 14 gauge (203 mm by 51 mm by minimum 2 mm) channel.
    b. Bolt Holes: Both flanges.
    c. Material: As scheduled on Drawings.
2. Blades:
    a. Style: Airfoil-shaped, double-skin.
    b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
    c. Minimum 14 gauge (2 mm) equivalent thickness.
    d. Material: As scheduled on Drawings.
    e. Width: 5 inches to 8 inches (127 mm to 203 mm) maximum.
3. Bearings: Stainless steel sleeve pressed into frame.
4. Seals:
    a. Blade Seals: As scheduled on Drawings.
    b. Jamb Seals: Compressible stainless steel located between blade edge and jamb.

5. Linkage:
   a. Side linkage out of airstream.
   b. Constructed of minimum 10-gauge (3.5-mm) galvanized steel clevis arms with minimum 3/16 inch by 3/4 inch (4.8 mm by 19 mm) plated steel tie bars pivoting on minimum 3/8-inch (9.5-mm) diameter stainless steel pivot pins with lock-type retainers.
6. Axles:
   a. Minimum 3/4 inch (19 m) diameter, hex-shaped, mechanically attached to blade.
   b. Material: As scheduled on Drawings.
7. Performance Data: As scheduled on Drawings.
8. Accessories: As scheduled on Drawings.
9. Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
   c. TAMCO.
   d. Greenheck.

2.05 CONTROL DAMPER OPERATORS

A. General:

1. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).
2. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.
3. Coordinate exact quantity of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
4. Provide operators for motorized dampers and motorized louvers.

B. Electric Damper Operators:

1. Performance: As scheduled on Drawings.
2. Mounting: External side plate.
3. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.
4. Furnished with external adjustable stops to limit stroke.
5. Operators on modulating dampers that are to be sequenced with other control devices shall have full relay type pilot positioner and interconnecting linkage to provide mechanical feedback that will accurately position and control damper.
6. Intake, relief, and exhaust dampers shall close and return dampers shall open on control failure, unless indicated otherwise.

7. Operating Torque:
    a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).
    b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 1-inch WC air pressure on damper blades:
        1) Opposed-Blade Dampers: Minimum 5 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.
        2) Parallel-Blade Dampers: Minimum 7 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.
8. Manufacturers:
    a. Belimo.
    b. Neptronic.
    c. Siemens Building Technologies.
    d. Johnson Controls.
    e. Honeywell.

2.06 ELECTRIC THERMOSTATS (T)

A. 7-Day programmable Thermostat:

1. Heating and Cooling Stages:
    a. Multi stage cooling and heating electronic control.
    b. Staging delay between each cycle.
    c. Visual indication of activation of each stage.
2. Temperature Scale: Furnish 50 to 90 degrees F dial.
3. 7-Day programmable.
4. External adjustments.
5. Operator interface to consist of temperature adjustment, LCD room temperature display, and visual indication of each cooling and heating stage activation.
6. Insulating back, where exterior wall mounting is indicated.
7. Adjustable “dead band” between heating and cooling to be between 4 degrees F and 20 degrees F.
8. Power loss memory for restoration of sequence of operation in event of power loss.
9. Refer to Section 23 09 00, Instrumentation and Control Devices for HVAC, for additional controller operation options.

B. Electric thermostat:

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 50 to 90 degrees F dial.
3. External adjustments.
4. Adjustable sensitivity.
5. Insulating back where exterior wall mounting is indicated.
6. Nonlocking wire protective guard.

2.07 ELECTRONIC SENSORS

A. Temperature:

1. General Requirements:
   a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.
   b. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.
   c. The following point types (and accuracy of each) are required, and their associated accuracy values include errors associated with sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Room Temperature	± 0.5°F
Duct Temperature	± 0.5°F
All Others	± 0.75°F

2. Room Temperature Sensors with Integral Display:
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Integral LCD display and four button keypad with the following capabilities:
      1) Display room and outside air temperatures.
      2) Display and adjust room comfort set point.
      3) Display and adjust fan operation status.
      4) Timed override request pushbutton with LED status for activation of after-hours operation.
      5) Display controller mode.
      6) Password selectable adjustment of set point and override modes.

3. Duct Temperature:
   a. Accuracy: Plus or minus 1 degree F.
   b. Range:
      1) Heating: 40 to 140 degrees F.
      2) Cooling: 30 to 100 degrees F.
   c. Element:
      1) Rigid insertion, 12 inch length, through sealed opening in center of duct.
      2) Averaging, for ducts or plenums with any dimension greater than 36 inches. Sealed opening in duct. Sensing element incorporated in copper capillary a minimum of 20 feet long, serpentined across full area of airflow.
4. Outdoor Temperature:
   a. Accuracy: Plus or minus 1 degree F.
   b. Range: Minus 40 to 140 degrees F.
   c. Cover: Weathertight, with sealed conduit connection and sun shield.

B. Position Indicator:

1. 0 to 100 percent open, for damper, inlet vane, or similar.
2. Potentiometer, 0 to 2,000 ohm equals 0 to 100 percent.

C. Relative Humidity:

1. Room Relative Humidity.
2. Accuracy: Plus or minus 2 percent.
3. Range: 10 to 95 percent.
4. Solid state.

D. Current Sensors (CS):

1. Fixed Setpoint, Digital Output Current Switch:
   a. Application: Monitoring status of direct drive equipment.
   b. Current-operated solid state relay.
   c. Split core design.
   d. Trip Setpoint: Fixed.
   e. Output: Digital switch.
   f. Sensor Power: Induced from line.
   g. Manufacturer and Product: Veris; Hawkeye 600/800.
2. Adjustable Setpoint, Digital Output Current Switch:
   a. Application: Monitoring status of belt drive equipment.
   b. Current-operated solid state relay.
   c. Split core design.
   d. Trip Setpoint: Adjustable.

e. Output: Digital switch, with status LED.
f. Sensor Power: Induced from line.
g. Manufacturer and Product: Veris; Hawkeye 708/908.

2.08 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0- to 5-volt) converters with zero span adjustments for use with analog inputs.
2. Limited range thermistors are acceptable provided they sense expected range for point at specified accuracy with 0- to 5-volt output.
3. Auxiliary contacts in each motor starter, Work of Division 26, Electrical.
4. START/STOP relay module for either momentary or maintained switch action as indicated.

B. Pilot Relays:

1. Plug-in type.
2. Interchangeable.
3. Mounted on a circuit board.
4. Wired to numbered terminal strips.

C. Flow Element and Switch, Thermal (FS):

1. General:
   a. Function: Monitor airflow and provide contact closure at setpoint.
   b. Type: Thermal dispersion flow switch using a heated active RTD and a reference RTD temperature sensor to detect rate of flow as a function of temperature difference between the two sensors.
   c. Double-pole, double-throw “Dry” relay contacts rated at a minimum of five amps.
2. Service:
   a. Ventilation airflow: Air, unless otherwise noted.
3. Performance:
   a. Setpoint: As noted
      1) Factory calibration for constant speed systems: The monitoring ventilation alarm shall be activated if the airflow switches read a reduction of the airflow of 15 percent or more from the design airflow showed in the contract documents for every system being monitored.
      2) Accuracy: Greater of plus or minus 5.0 percent of reading or plus or minus 2 sfps (air).

3) Repeatability: Plus or minus 0.5 percent of reading, at constant temperature and pressure.
4) Temperature, Operating: Sensor Element: Minus 40 degrees F to plus 350 degrees F.
5) Pressure, Operating: To 3,500 psig at 70 degrees F, to 2,350 psig at 500 degrees F.

4. Features:
   a. Materials: Type 316 stainless steel, unless otherwise noted.
   b. Temperature Compensation: Via factory calibration.
5. Element Insertion: 2 inches from tip of probe to connection, unless otherwise noted.
6. Electronics:
   a. Location: Integral, unless otherwise noted.
   b. Operating Temperature: Minus 40 degrees F to 140 degrees F.
   c. Calibration Circuit: Built in for field adjustment of setpoint.
7. Signal Interface Contact: Field selectable two SPDT or one DPDT, rated 6 amps at 115V ac, 220V ac or 24V dc. SPDT with separate setpoints.
8. Enclosure:
   a. Type: NEMA 4X.
   b. Enclosure: Type 316 stainless steel, unless otherwise noted.
   c. Approval: Hazardous locations, Class I and Class II, Division 1 and Division 2, Groups B, C, D, E, F, and G.
9. Ancillaries:
   a. Furnish interconnecting cable if remote electronics specified.
      1) Cable Jacket: PVC, unless otherwise noted.
      2) Cable Length: 10 feet, unless otherwise noted.
10. Power: 120V ac, 60-Hz, unless otherwise noted.
11. Identifying Tag: Stainless steel.
12. Manufacturer:
    a. Fluid Components, Inc.
    b. Ameritrol, Inc.

D. Duct Mounted Ionization Detection (SD):

1. Furnish duct smoke detectors for air handling systems, number and location as shown on Drawings.
2. Type: Duct mounted, suitable for airstream sensing.
3. Voltage: 120V ac.
4. Detector Type: Ionization.
5. Furnish with remote reset button or key switch.
6. Include mounting bracket for installation on the ductwork.
7. Coordinate with other trades to accomplish specified Automatic Smoke Detection shutoff control sequence.

8. Manufacturers and Products:
    a. BRK Electronics; Model DH1851AC.
    b. Pyrotronics Pyr-Alarm.

PART 3 EXECUTION

3.01 INSTALLATION

A. Control Dampers:

1. Install at locations indicated on Drawings and in accordance with manufacturer's instructions.
2. Install square and free from racking with blades running horizontally.
3. Operate opposed blade dampers from a power blade or drive axle.
4. Bracing:
    a. Install for multiple section assemblies to support assembly weight and to hold against system pressure.
    b. Install at every horizontal and vertical mullion.

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 760, Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): 15, Safety Standard for Refrigeration Systems.
3. American Society of Mechanical Engineers (ASME):
   a. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   b. B31.5, Refrigeration Piping and Heat Transfer Components.
4. American Welding Society (AWS):
   a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. BRH, Brazing Handbook.
5. ASTM International (ASTM): B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
6. National Electrical Manufacturers Association (NEMA).
7. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. NRTL: National Recognized Testing Laboratory.

1.03 SUBMITTALS

A. Action Submittals: Manufacturer’s data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.

B. Informational Submittals:

1. Welding certificates.
2. Field quality control; test report.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Safety Code Compliance: Comply with applicable portions of ASHRAE 15.

B. Brazing: Comply with applicable requirements of ASME B31.5 pertaining to brazing of refrigerant piping for shop and Project Site locations.

C. Installer: A firm with at least 5 years of successful installation experience on projects with refrigerant piping similar to that required for this Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Refrigerant piping shall be cleaned, dehydrated, and sealed when delivered.

B. Store piping in clean and protected area with end caps in place.

PART 2 PRODUCTS

2.01 MATERIALS

A. Material and dimensional requirements for field assembled refrigerant piping, valves, fittings and accessories shall conform to ASHRAE 15 and ASME B31.5, except as hereinafter specified.

B. Piping, 3 Inches and Smaller: Copper, Type ACR tube, ASTM B280, copper No. 122, hard-drawn temper. Brazed joints required.

C. Fittings for Copper Tube: Wrought-copper/bronze solder-joint fittings in accordance with ASME B16.22.

D. Pipe Insulation: Refer to Section 23 07 00, HVAC Thermal Insulation.

2.02 MISCELLANEOUS PIPING PRODUCTS

A. Brazing Materials:

1. Except as otherwise indicated, provide 15 percent silver alloy brazing material for copper to copper and copper to brass fittings.
2. Comply with AWS A5.8M/A5.8 for brazing filler materials.

B. Refrigerant Specialties:

1. Refrigerant Suction Line Filter-Dryer:
   a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. Provide size recommended by refrigeration equipment manufacturer.
2. Refrigerant Liquid Line Dryer:
   a. Provide refrigerant liquid line filter-dryer for all units.
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
   e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:

1. Globe and Check Valves: Listed and labeled by an NRTL.
   a. Shutoff Valves:
      1) Forged brass, packed, back seating winged seal cap, 300 degrees F (140 degrees C) temperature rating 500 psi working pressure.
      2) Maximum Opening Pressure: 0.5 psig.
      3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
   b. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
2. Solenoid Valve: Listed and labeled by an NRTL.
   a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 1/2-inch conduit adapter, 250 degrees F (121 degrees C) temperature rating 500 psi working pressure.
   b. Provide valve only if recommended by air-conditioning equipment manufacturer.

c. Manual Operator: Provide optional manual operator to open valve.
d. Manufacturers:
1) Alco Controls Div.; Emerson Electric Co.
2) Automatic Switch Co.
3) Parker Hannifin Corp.

3. Thermostatic Expansion Valve:
a. Body Bonnet and Seal Cap: Forged brass or steel.
b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
c. Capillary and Bulb: Copper tubing filled with refrigerant.
d. Suction Temperature: 40 degrees F.
e. End Connections: Socket or flare.
f. Working Pressure: 700 psig.
g. Manufacturers:
1) Henry Technologies.
2) Parker Hannifin Corp.
3) Danfoss Group Global.

4. Safety Relief Valve:
a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
b. Seat Disk: Polytetrafluoroethylene.
c. Working Pressure: 500 psig.
d. Operating Temperature: 240 degrees F, maximum.
e. Manufacturers:
1) Henry Technologies.
2) Parker Hannifin Corp.
3) Danfoss Group Global.

D. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM

A. Install piping products in accordance with manufacturer's written instructions, applicable requirements of ASME B31.5, ASHRAE 15, and in accordance with recognized industry practices to ensure products serve intended function.

B. Install dryers on liquid and suction lines.

C. Refrigerant Piping:

1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.
3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.
5. Run piping as shown on Drawings, taking care to avoid interference with other piping, conduit or equipment. Except where specifically indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.
6. Trapping of lines shall not be permitted, except where indicated.
7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install refrigerant piping in protective conduit where installed belowground.
12. Install accumulator in suction line near condensing unit.
13. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
14. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.
    c. Install traps and double risers to entrain oil in vertical runs.
    d. Liquid lines may be installed level.

D. Pipe Sleeves:

1. Provide pipe sleeves of suitable size for pipe and tubing that penetrate building structure.
2. Secure sleeves in position and location before and during construction. Space between pipe and sleeves, or between insulation and pipe sleeves, shall be not less than 1/4 inch between outside of pipe or insulation, and inside wall of sleeves.

3. Sleeves for uninsulated pipes shall have ends flush with finished wall surfaces; provide pipe or tubing as above with outside perimeter of pipe caulked to sleeve.
4. Extend sleeves for insulated pipes 1/2 inch from wall faces and caulk to sleeve on both sides.
5. Seal terminal ends of pipe insulation with mastic.
6. Extend sleeves for lines passing through floors 3 inches above finished floor slab and caulk to slab.
7. Seal penetrations through fire and smoke barriers according to Section 07 84 00, Firestopping.

E. Braze cap (seal) ends of piping when not connected to mechanical equipment.

3.02 SOLDER JOINTS

A. Solder joints shall not be used for joining refrigerant piping systems.

3.03 BRAZED JOINTS

A. Braze copper piping with silver solder complying with AWS A5.8M/A5.8.

B. Brazed Joints:

1. Construct joints according to AWS *Brazing Handbook* Chapter “Pipe and Tube”.
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
3. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

C. Inside of tubing and fittings shall be free of flux.

D. Clean parts to be joined with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled.

E. Cool joints in air and remove flame marks and traces of flux.

F. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel air.

G. When brazing, 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.

3.04 PIPE HANGERS

A. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

3.05 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in the manner shown, and comply with equipment manufacturer's instructions where not otherwise indicated.

3.06 FIELD QUALITY CONTROL

A. General:

1. Notify Engineer at least 48 hours before testing is performed.
2. Furnish equipment required for tests.
3. Group as many systems together as possible when testing in order to consolidate number of test inspections.

B. Leak Test:

1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
2. Perform initial test with dry nitrogen to 300 psig minimum using soap solution to test joints.
3. Evacuate system after initial test and charge system with refrigerant or dry nitrogen, 20 percent refrigeration mixture to 600 psig minimum.
4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
    a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.

C. Evacuation, Dehydration, and Charging:

1. After system is found to be without leaks, evacuate system using reliable gauge and vacuum pump capable of pulling a vacuum of at least 1-mm Hg absolute (29.88-inch Hg gage).
2. Evacuate system with vacuum pump until temperature of 35 degrees F (2 degrees C) is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.

4. Maintain vacuum on system for minimum of 12 hours after closing valve between vacuum pump and system. If system holds vacuum for 12 hours it is ready for charging.
5. Break vacuum with refrigerant gas or dry nitrogen gas, allowing pressure to build up to 2 psi (15 kPa).
6. Install new filter-dryer core in charging line.
7. Repeat evacuation procedure and complete charging of system; provide full operating charge.

3.07 ADJUSTING

A. General:

1. Adjust high-pressure and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
2. Adjust setpoint temperature of air-conditioning or chilled-water controllers to system design temperature.
3. Perform following adjustments according to manufacturer's written instructions before operating refrigeration system:
   a. Open shutoff valves in condenser water circuit.
   b. Verify compressor oil level is correct.
   c. Open compressor suction and discharge valves.
   d. Open refrigerant valves, except bypass valves that are used for other purposes.
   e. Check open compressor-motor alignment and verify lubrication for motors and bearings.

B. 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 AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
   c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
   e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
   g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
   h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
   j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
   k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

l. A1011/A1011M, 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.
m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
7. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Duct Construction Standards.
   b. Guidelines for Seismic Restraints of Mechanical Systems.
   c. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
   d. HVAC Air Duct Leakage Test Manual.

9. Underwriters Laboratories Inc. (UL):
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.
    c. 555, Standard for Safety Fire Dampers.
    d. 555S, Standard for Safety Smoke Dampers.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: cubic feet per minute.
2. FPM: feet per minute.
3. PCF: pounds per cubic foot.
4. WC: water column.

B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:

1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
2. Joints, duct surface connections including:
    a. Girth joints.
    b. Branch and subbranch intersections.
    c. Duct collar tap-ins.
    d. Fitting subsections.
    e. Louver and air terminal connections to ducts.
    f. Access door, and access panel frames and jambs.
    g. Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
    a. Rectangular, Rigid Round, and Oval Ductwork:
        1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
        2) SMACNA Figure Numbers for each shop fabricated item.
        3) Reinforcing details and spacing.
        4) Seam and joint construction details.
        5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

b. Ductwork Accessories:
   1) Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
      a) Fittings and volume control damper installation (both manual and automatic) details.
      b) Sealing materials.
      c) Dampers; include leakage, pressure drop, and maximum back pressure data.
      d) Duct-mounted access panels and doors.
      e) Flexible ducts.
      f) Sheet metal fasteners.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA Duct Construction Standards relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.

E. Changes or alterations to layout or configuration of duct system shall be:

1. Specifically approved in writing by Engineer.
2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.

B. If fabricated sound-lined ductwork gets wet during installation, remove and dispose of ductwork from the Site.

C. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

D. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

E. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Drawings.

2.02 GENERAL

A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions, and shall be increased in both dimensions by twice the thickness of the liner.

C. Ductwork thinner than 26-gauge will not be allowed.

D. Ductwork Interior Surfaces:

1. Smooth.
2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.
3. Seams and joints shall be external.
4. For ductwork that is required to be reinforced, use only external reinforcing.

2.03 SHEET METAL MATERIALS

A. Construct metal duct systems from materials as indicated in Ductwork Schedule.

B. Where no specific ductwork materials are indicated in Specifications or on Drawings, galvanized steel sheet metal shall be basis of Contract.

C. Galvanized Steel Ductwork:

1. Comply with ASTM A653/A653M and ASTM A924/924M.
2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
3. Sheet Designation: CS Type B.
4. Applicable Specification: ASTM A653/A653M.
5. (Zinc) Coating Designation: G90.
6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.

7. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
8. Provide sheet metal packaged and marked as specified in ASTM A700.

D. Aluminum Ductwork:

1. Comply with ASTM B209.
2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.

E. Stainless Steel Ductwork:

1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
2. Stainless Steel Sheet: Type 304, unless indicated otherwise.
3. Gauge shall comply with SMACNA manual, unless specified otherwise.
4. Finish: cold-rolled, bright finish, except as otherwise noted.

F. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

G. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.04 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.

C. Solvent-Based Sealants:

1. Ultraviolet light resistant.
2. Mildew resistant.
3. Flashpoint: Greater than 70 degrees F, SETA CC.
4. Manufacturers and Products:
   a. Hardcast, Inc.; Versagrip 102.
   b. Rectorseal; AT-33.
   c. Childers CP-140.

D. Water-Based Sealants:

1. Listed by manufacturer as nonflammable in wet and dry state.
2. Manufacturers and Products:
   a. Foster; Series 32.
   b. Childers; CP-145A, 146.
   c. Rectorseal; Airlok 181.

2.05 FIRESTOPPING

A. Refer to Section 07 84 00, Firestopping.

2.06 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.
2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
2. Aluminum Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel, complete with bonded metal and fiber washer for dielectric separation.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.
3. Stainless Steel Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.

2.07 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated in Ductwork Schedule.

B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 2-inch WC pressure class shall be basis of Contract.

2.08 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible,unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

2.09 RECTANGULAR DUCTWORK FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. Elbows:

1. Fit square-turn elbows with vane side rails.
2. Shop fabricate double-blade turning vanes of same material as ductwork.
3. Fabricate with equal inlet and outlet.
4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
5. Manufacturers:
   a. Elgen.
   b. Duro-Dyne.

2.10 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections**.**

2.11 RECTANGULAR DUCTWORK INSULATION LINER

A. Location: Provide ductwork with internal insulation liner where indicated on Drawings or in Ductwork Schedule.

B. Material:

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean.
2. Black composite coating on surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
3. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
4. Potential heat value not exceeding 3,500 Btu per hour per pound when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
5. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
6. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139.
7. Manufacturers and Products:
   a. CertainTeed; Toughgard.
   b. JohnsManville; Linacoustic RC.
   c. Knauf; Duct Liner M.

C. Thickness: Minimum 1 inch(es) or greater thickness where indicated on Drawings or Ductwork Schedule.

D. R-Value: Minimum 6 hours foot squared degrees F per Btu or greater, where indicated on Drawings or Ductwork Schedule.

E. Liner Adhesive: In accordance with NFPA 90A and ASTM C916.

F. Mechanical Fasteners:

1. Same material as ductwork, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.
2. Provide fasteners that do not damage liner when applied as recommended by manufacturer, that do not cause leakage in duct, and will indefinitely sustain 50-pound tensile dead load test perpendicular to duct wall.
3. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
4. Adhesive for Attachment of Mechanical Fasteners: In accordance with Fire Hazard Classification of duct liner system.

G. Liner Application:

1. Ductwork liner shall be applied at time of ductwork manufacture in an approved sheet metal workshop.

2. Adhere single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
3. Apply coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
4. Butt transverse joints without gaps and coat joint with adhesive.
5. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
6. Longitudinal Joints:
   a. Shall not occur except at corners of ducts, unless size of duct and standard liner product dimensions make longitudinal joints necessary.
   b. Apply adhesive coating on longitudinal seams in ducts exceeding 2,500 fpm air velocity.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter, at 3 inches from transverse joints, and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing airstream with metal nosing that are either channel or "Z" profile or are integrally formed from duct wall at the following locations:
   a. Fan discharge.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts.
9. Seal insulation edges.
10. Repair abrasions or tears with mastic.

2.12 DOUBLE WALL INSULATED DUCTWORK

A. General:

1. Double wall duct system consisting of outer sheet metal pressure shell, internal sheet metal liner, with insulating material in annular space.
2. Location: Provide where indicated on Drawings or in Ductwork Schedule.

B. Construction:

1. Outer shell gauge shall be based upon actual outer shell dimensions.
2. Inner liner secured to outer shell with mechanical fasteners that maintain metal liner distance from duct without compressing insulation.
3. Inner liner:
   a. Solid sheet metal liner, with no insulation liner exposed to airstream, unless indicated to be perforated.
   b. Same material as outer pressure shell, unless indicated otherwise.

C. Insulation:

1. Void space between liner and outer pressure shell shall be filled with fiberglass insulation, material and installation in accordance with Article Rectangular Ductwork Insulation Liner.
2. Thickness: Minimum 1 inch(es) or greater thickness where indicated on Drawings or Ductwork Schedule.
3. R-Value: Minimum 6 hours foot squared degrees F per Btu or greater, where indicated on Drawings or Ductwork Schedule.

D. Liner termination:

1. Terminate internal liner with duct build-outs (metal hat sections) where double wall ductwork connects to single wall ductwork or to any uninsulated component.
2. Secure build-outs to duct wall with bolts, screws, rivets, or welds.
3. Terminate liner at fire dampers at connection to fire damper sleeve.

2.13 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Basic Round Diameter: As used in this Article, is inside diameter of size of round duct.

C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.

D. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

E. Ductwork seams of Snaplock type shall not be used.

2.14 RIGID ROUND DUCTWORK FITTINGS

A. Construct rigid round ductwork fittings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.

B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.

C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

D. Elbows:

1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two piece segment elbows are not allowed, except with turning vanes.
2. Segmented Elbows: Fabricate with welded construction.
3. Round Elbows 8 Inches and Smaller:
   a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees configuration.
   b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 inches and 4-1/2 inches) elbows with segmented construction.
4. Round Elbows 9 Inches Through 14 Inches:
   a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.
   b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

2.15 ROUND DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.

2.16 INSULATED FLEXIBLE DUCT

A. Fabricate in accordance with:

1. UL 181, Class 1.
2. NFPA 90A and NFPA 90B.

B. Construction:

1. Outer Jacket: Fire retardant reinforced metalized vapor barrier jacket with reinforced cross-hatched scrim having a permeance of not greater than 0.1 perm when tested in accordance with ASTM E96/E96M, Procedure A.
2. Inner Liner: Tri-laminate of aluminum foil, fiberglass, and aluminized polyester.
3. Reinforcing: Galvanized steel wire helix, mechanically locked to and encapsulated by inner liner fabric.
4. Insulation:
   a. Factory insulated with fiberglass insulation.
   b. R-value: 6.0 minimum at a mean temperature of 75 degrees F.
5. Internal Working Pressure: Rating shall be minimum 4-inch WC positive and 5-inch WC negative, with bursting pressure of at least 2-1/2 times working pressure.
6. Air Velocity Rating: 4,000 fpm, minimum.

C. Environment: Suitable for continuous operation at temperature range of minus 20 degrees F to plus 200 degrees F.

D. Manufacturers:

1. Flex-Master.
2. Thermaflex.
3. Hart & Cooley.

2.17 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Ductwork support system shall be designed and provided by HVAC contractor in accordance with SMACNA Manual referenced for type of duct system being installed.
2. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
3. Duct hanging system shall be composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
4. Wire hangers are not acceptable.
5. Hanger Spacing:
   a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.
   b. Ducts Over 61 inches in Largest Dimension: 8 feet, maximum.

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:

1. Galvanized Steel Ductwork:
   a. Indoors: Carbon steel, zinc electroplated.
   b. Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
2. Aluminum Ductwork Indoors and Outdoors:
   a. Carbon steel, hot-dipped galvanized after fabrication.
   b. Non-metallic pad between lower attachment and ductwork, to achieve dielectric separation.
3. Stainless Steel Ductwork Indoor and Outdoor: Stainless steel, same ASTM Grade as ductwork.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.

2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
3. Upper Attachment (Concrete):
   a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.
   b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
   c. Concrete attachments shall be made of steel.

D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.18 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
3. Comply with NFPA 90A and NFPA 90B requirements.
4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
3. Fabric:
   a. Comply with NFPA 701 or UL 214 (except teflon coated).
   b. Woven polyester or nylon for most applications.
   c. Woven fiberglass for high temperature applications.
   d. Coating: Vinyl.

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
2. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch-wide sheet metal.

3. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch-wide sheet metal.
4. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch-wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial.
2. Ventfabrics.
3. Duro-Dyne.

2.19 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.
2. On ductwork where largest side dimension is less then 16 inches, furnish inspection doors at least 8 inches by 8 inches.
3. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

1. Size: 18-inch and 24-inch diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
3. Manufacturer and Product: Flexmaster; Inspector Series.

C. Manufacturers:

1. Ventlok.
2. Duro-Dyne.
3. Flexmaster.

2.20 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
2. Align operating handle with damper blade.
3. Provide 2-inch standoff bracket for insulated duct systems.

4. Damper Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
5. Operator Manufacturers:
   a. Accessible Ductwork: Ventlok.
   b. Accessible Insulated Ductwork: Ventlok.
   c. Concealed Ductwork: Ventlok.

B. Manual Opposed-Blade Balancing Dampers:

1. Externally operated gang airfoil, damper blades.
2. Fabricate from same material as ductwork.
3. Stainless steel or nylon sleeve bearings.
4. Construction shall have interlocking edges and maximum 10-inch blade width.
5. Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.

2.21 BACK DRAFT DAMPERS

A. General: Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.

B. Steel Frame, Nonmetallic Blades:

1. Fabrication:
   a. Frame: 2 inches by minimum 18-gauge (51 mm by minimum 1.6 mm) galvanized steel with windstops to reduce backflow.
   b. Blades:
      1) Style: Single piece, independent.
      2) Action: Parallel.
      3) Material: Noncombustible, neoprene coated fiberglass.
      4) Orientation: Horizontal.
      5) Width: Maximum 6 inches (152 mm).
   c. Rear Bird Screen: Galvanized expanded metal.
   d. Mounting:
      1) Suitable for mounting in vertical or horizontal airflow up positions.
      2) Configured for positions as shown on Drawings.
   e. Finish: Mill galvanized.
2. Performance Data:
   a. Temperature Rating: Withstand minus 30 degrees to 200 degrees F (minus 34 degrees to 93 degrees C).
   b. Maximum Back Pressure: 4-inch WC (1.0 kPa).

c. Maximum System Air Velocity: 1,000 fpm (5.1 m/s).
d. Maximum Spot Air Velocity: 1,200 fpm (6.1 m/s).

3. Manufacturers and Products:
a. Ruskin; Model NMS2.
b. Vent Products, Co.

C. Aluminum, Counterbalanced, Standard Duty:

1. Fabrication:
a. Frame: 2 inches by minimum 0.06 inch (51 mm by minimum 1.5 mm), 6063-T5 extruded aluminum channel with front flange and rear flange and mitered corners.
b. Blades:
1) Style: Single piece, overlap frame.
2) Action: Parallel.
3) Material: Minimum 0.025-inch (0.6 mm) 6063-T5 formed aluminum.
4) Width: Maximum 6 inches (152 mm).
c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
e. Linkage: Concealed in frame.
f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
h. Mounting:
1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
2) Configured for positions as shown on Drawings.
i. Finish: Mill aluminum.
2. Performance Data:
a. Temperature Rating: Withstand minus 40 degrees to 200 degrees F (minus 40 degrees to 93 degrees C).
b. Maximum Back Pressure: 2-inch WC (500 Pa).
c. Maximum Spot Air Velocity: 1,000 fpm (5 mps).
d. Operation of Blades:
1) Start to Open: 0.01-inch WC (0.002 kPa).
2) Fully Open: 0.06-inch WC (0.01 kPa).
e. Pressure Drop: Maximum 0.04-inch WC (0.01 kPa) at 1,000 fpm (305 mpm) through 24-inch by 24-inch (610 mm by 610 mm) damper.

3. Manufacturers and Products:
   a. Ruskin; Model CBD2.
   b. Greenheck; Series 160, 360, 460.

2.22 FIRE, FIRE/SMOKE, SMOKE DAMPERS

A. Duct Mounted Fire Dampers in Fire Walls with Rating of 2 Hours or Less:

1. NFPA 90A rated for 1-1/2-hour service.
2. Blades, frame, and mounting angles same material as ductwork.
3. Accordion style folded blades or air foil type blades for multiblade dampers.
4. 165 degrees F fusible link.
5. Approved for installation with 2-hour fire rating.
6. Rated, manufactured, tested, and approved in accordance with UL 555.
7. Blades out of airstream when open (Style B).
8. Furnish with sleeved frame for duct connections.
9. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
10. Corrosive Service Dampers: Type 316 stainless steel.
11. Manufacturers:
    a. Nailor Industries.
    b. Ruskin.

B. Combination Fire/Smoke Dampers:

1. General:
   a. UL Listed according to UL 555S.
   b. UL Listed for 1-1/2 hour rating according to UL 555.
   c. As part of UL qualification, smoke dampers shall have demonstrated capacity to operate (to open and close) under HVAC system operating conditions, with pressures up to 4-inch WC in closed position, and 2,000-fpm air velocity in open position.
2. Fusible Link: Replaceable, 165 degrees F.
3. Bearings: Stainless steel sleeve turning in extruded hole in frame. Galvanized bearings are not acceptable.
4. Controlled Closure: Heat-actuated release device to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable.
5. Leakage Class: In accordance with UL 555S Class I (4 cfm per square foot at 1-inch WC).
6. Frame and Blades: 16-gauge galvanized steel.
7. Mounting Sleeve: Factory installed, 18-gauge galvanized steel, length to suit wall or floor application.
8. Manufacturer and Product: Ruskin; FSD Series.

C. Smoke Dampers:

1. General:
   a. UL Listed according to UL 555S.
   b. As part of UL qualification, smoke dampers shall have demonstrated capacity to operate (to open and close) under HVAC system operating conditions, with pressures up to 4-inch WC in closed position, and 2,000-fpm air velocity in open position.
2. Bearings: Stainless steel sleeve turning in extruded hole in frame. Galvanized bearings are not acceptable.
3. Controlled Closure: Heat-actuated release device to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable.
4. Leakage Class Class I (4 CFM per square foot at 1-inch WC).
5. Frame and Blades: 16-gauge galvanized steel.
6. Mounting Sleeve: Factory installed, 18-gauge galvanized steel, length to suit wall or floor application.
7. Manufacturer and Product: Ruskin; SD Series.

2.23 CONTROL DAMPERS

A. Refer Section 23 09 13, HVAC Controls, Field Components, and Instruments, for requirements.

2.24 EXTERNAL DUCT INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

2.25 MISCELLANEOUS ACCESSORIES

A. Louver and Grille Blank-Off Sections:

1. Fabricate from 20-gauge sheets of same material as louver/grille.
2. Line with sound attenuation/insulating material.
3. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.

B. Auxiliary Drain Pans:

1. Dimensions: Minimum 6 inches larger in both dimensions than equipment it is serving and 2 inches high, minimum.
2. Construction: 16-gauge stainless steel with welded joints. Pans shall be watertight and have hemmed edges.

3. Drain Connection:
   a. Minimum 1-inch IPS or as shown on Drawings.
   b. Locate at lowest point of drain pan.
   c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

C. Accessories Hardware:

1. Instrument Test Holes:
   a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
   b. Size to allow insertion of pitot tube and other testing instruments.
   c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
   a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
   b. Provide in sizes from 3 inches to 18 inches to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.

3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
   a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
   b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
   b. Fit collars snugly around ducts and insulation.
   c. Same gauge and material as duct.
   d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
   e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.
3. Limit clearance to 1 inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.

E. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

F. Shower Room and Toilet Room Exhaust Ductwork:

1. Joints and Seams: Seal watertight.
2. Slope branch ducts downward to grille.

G. Fume Hood, and Laboratory Exhaust Ductwork:

1. Seal joints and seams with chemical-resistant mastic.
2. Rivet butt joints with minimum of eight pop rivets.

3.02 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low Pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct tap with a gasket or sealed with sealant as specified for medium pressure ductwork.
2. Determine location of spin-in after outlet location is determined.
3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.

3. Make offsets with maximum angle of 45 degrees.
4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
3. Mechanical Joint Option:
   a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.
   b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
   c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
   d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
   e. Conform to SMACNA Class A sealing requirements.

3.03 RIGID ROUND OR OVAL DUCTWORK

A. General: Except where interrupted by fittings, install round ducts in lengths as long as possible to minimize joints.

B. Rigid Round or Oval Ductwork Joints:

1. Rigid round ductwork joints shall be in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.
2. Single and Double Wall Supply and Return System Joints:
   a. Less than 36 Inches: Slip coupling.
   b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.
3. Single and Double Wall Exhaust and Return System Joints:
   a. Spiral Seam Duct: Welded flanged connector.
   b. Longitudinal Seam Duct: Van Stone flange connector.

3.04 INSULATED FLEXIBLE DUCT

A. Installation:

1. Where shown, between branch duct and ceiling diffusers and grilles.
2. Without sags, kinks, sharp offsets, or elbows.
3. As straight and taut as possible.

B. Connection: Connect flexible ductwork to round collars, air distribution devices, and terminal units in accordance with flexible duct manufacturer's recommendations.

C. Length: Maximum length of low-pressure flexible duct (construction pressure class up to 2-inch WC) to be 8 feet.

D. Flexible ductwork shall not pass through wall, floor, or fire resistant rated assembly.

3.05 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

H. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems.

3.06 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.07 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers as indicated on Drawings in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

D. Fire Dampers:

1. At ceiling grille and diffuser fire dampers, provide thermal blankets where required by local authorities.
2. Install 1-1/2-hour rated, unless otherwise indicated, at locations shown and in accordance with SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.

3.08 ACCESS DOORS

A. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:

1. Duct mounted fire damper.
2. Duct mounted smoke or ionization detector.
3. Motorized damper.
4. Turning vane.
5. Volume damper.
6. Automatic damper.
7. Temperature controller.

3.09 EXTERNAL DUCT INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

3.10 MISCELLANEOUS ACCESSORIES

A. Auxiliary Drain Pans:

1. Under equipment for which pan is shown on Drawings and under all horizontal air handling units located above ceilings and piping located in ceiling space directly above computer facility areas; furnish and install auxiliary drain pans.
2. Route drain lines to nearest floor or hub drain independent of any other drain.
3. Slope drain pans toward drain connection to promote drainage.

B. Louver and Grille Blank-Off Sections: Attach airtight to louver or grille and install to allow for easy removal.

C. Inspection Plates and Test Holes:

1. Where required in ductwork for balance measurements.
2. Test holes shall be airtight and noncorrosive with screw cap and gasket.
3. Extend cap through insulation.

3.11 DUCT SEALING

A. Seal duct seams and joints as follows: As indicated on Ductwork Schedule.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Seal externally insulated ducts prior to insulation installation.

D. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

E. Seal all audible leaks.

3.12 FIRESTOPPING

A. Refer to Section 07 84 00, Firestopping.

3.13 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.14 PROTECTION OF INSTALLED WORK

A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.

B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.15 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

END OF SECTION

SECTION 23 34 00
HVAC FANS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 204, Balance Quality and Vibration Levels for Fans.
   e. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   f. 300, Reverberant Room Method for Sound Testing of Fans.
   g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA): 45, Standard on Fire Protection for Laboratories Using Chemicals.
8. Occupational Safety and Health Act (OSHA).

9. Society for Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
10. Underwriters Laboratories Inc. (UL): 507, Safety Standard for Electric Fans.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. hp: Horsepower.
7. ODP: Open Drip Proof.
8. SWSI: Single Width, Single Inlet.
9. TEFC: Totally Enclosed, Fan Cooled.
10. UV: Ultra Violet

1.03 SUBMITTALS

A. Action Submittals:

1. Provide following for specified products:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer’s name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights.
    e. Fan sound power level data (reference 10 to power minus 12 watts) at design operating point.
    f. Fan Curves:
        1) Performance Curves Indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum revolutions per minute).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at duty point, including drive losses.
    g. Capacities and ratings.

h. Construction materials.
i. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
j. Wheel type, diameter, maximum revolutions per minute for fan class, operating revolutions per minute, and tip speed.
k. Motor data, including service factor and operating horsepower, as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
l. Belt service factor.
m. Drive assembly horsepower rating.
n. Sheave horsepower rating.
o. Power and control wiring diagrams, including terminals and numbers.

2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. "Or Equal" Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Recommended procedures for protection and handling of products prior to installation.
3. Manufacturer's installation instructions.
4. Manufacturer's Certificate of Compliance for the following: Motors specified to be premium efficient type.
5. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
6. Test reports.
7. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Performance Ratings: Tested in accordance with AMCA 210.

B. Sound Ratings: Tested in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, and special tools:

Item	Quantity
Vee Belts	One complete set per unit
Special tools required to maintain or dismantle	One complete set for each different size unit

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedule. Refer to Drawings.

2.02 GENERAL

A. Spark Resistant Construction: Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

B. Operating Limits: Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408.

C. Acoustical Levels: Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

D. Fan Drives:

1. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
2. Furnish multiple drive belts where motor horsepower is 2 hp or larger.
3. Sheaves:
   a. Capable of providing 150 percent of motor horsepower.
   b. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.

4. Drive Adjustment:
   a. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
   b. Provide trial and final sheaves, as well as drive belts, as required.
5. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
6. Provide speed test openings at shaft locations.
7. Belts: Oil and heat resistant, nonstatic type.
8. Motors:
   a. Motors 20 hp or Smaller:
      1) Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
      2) Final operating point shall be at approximate sheave midpoint.
   b. Furnish motors for V-belt drives with adjustable rails or bases.
9. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
10. Belt and Shaft Guards:
    a. Easily removable and to enclose entire drive assembly, meeting federal, OSHA requirements.
    b. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
    c. Bright yellow finish.

E. Finishes:

1. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.
   a. Parts cleaned and chemically pretreated with phosphatizing process.
   b. Alkyd enamel primer.
   c. Air dry enamel topcoat.
2. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
3. Stainless Steel Parts: Finished smooth and left unpainted.
4. Fiberglass Parts: Finished in accordance with Paragraph Fiberglass Material.

2.03 INLINE FAN, CENTRIFUGAL, SQUARE (050-EF-2,3,5 & 6)

A. General:

1. Factory-assembled, centrifugal, inline fan, square housing configuration; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Construction: All aluminum.
2. Integral duct collars.
3. Removable side panels, for ease of service.
4. Field convertible for side air discharge configuration.
5. Predrilled universal mounting brackets for vertical or horizontal installation.
6. Inlets: Aerodynamic aluminum venturi.
7. Corrosion-resistant fasteners.
8. Drive belt and bearings separated from air steam by enclosure.

C. Wheel:

1. Centrifugal backward inclined, 100 percent aluminum construction.
2. Precision machined cast aluminum hub.
3. Die-formed airfoil or backward inclined blades.
4. Matched to inlet venturi.
5. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished carbon steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style, relubricatable or sealed type.
   b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: Direct.

E. Accessories: Provide as scheduled in Equipment Schedule.

F. Manufacturers and Products:

1. Aerovent; Model SCDD (Direct).
2. Loren Cook; Model SQND (Direct).
3. Or “Equal”.

2.04 INLINE FAN, TUBULAR CENTRIFUGAL (050-EF-1)

A. General:

1. Factory-assembled tubular centrifugal fan, belt drive; including housing, fan wheel, drive assembly, motor, and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housings:

1. Material: Type 316 stainless steel.
2. Construction:
   a. Heavy-gauge rolled metal casing, with continuous seam welding.
   b. Air straightening vanes at fan outlet, integral with shaft, bearing support, and outer casing, fully welded.
   c. Bearing and drive components isolated from air stream within continuously welded tunnel.
   d. Lifting lugs welded to housing.
   e. Mounting brackets, welded to housing, as required for indicated fan arrangement.
3. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
4. Inlets: Die-formed bell mouth, matched to fan wheel inlet shroud.
5. Motor Base Plate: Minimum of 3/16-inch metal plate, welded to fan housing, to provide belt tensioning and adjustment.
6. Duct Flanges: Angle ring flanges, same diameter as housing, at fan inlet and outlet, heavy construction, factory drilled.

C. Wheel:

1. Material: Type 316 stainless steel construction.
2. Centrifugal, one-piece, nonoverloading, backwardly inclined blades.
3. Blades continuously welded to inlet shroud and backplate.
4. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished hot-rolled carbon steel.
   b. Keyed for sheave installation.
   c. Corrosion protection coating.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.

c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
d. Suitable for fan operation in vertical configuration.

3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to the specified fan revolutions per minute.
   c. Type: Belt.

E. Arrangement: Arrangement 9. Roof Mount Accessories:

1. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
2. Stack Cap:
   a. Factory fabricated with venturi.
   b. Same material as fan housing.
   c. Integral backdraft dampers.

F. Accessories: Provide as scheduled in Equipment Schedule.

G. Manufacturers and Products:

1. Aerovent; Model AFE.
2. Cook; Model TCNH-B.
3. Greenheck; Model TCB.

2.05 WALL FAN, PROPELLER, HEAVY DUTY (050-EF-4 & 030-EF-1)

A. General: Factory-assembled wall propeller fan; including housing, propeller, drive assembly, motor and accessories.

B. Housings:

1. Material: Aluminum.
2. Panel:
   a. Minimum 14-gauge sheet metal construction.
   b. Integral formed venturi orifice.
   c. Continuously welded corners.
   d. Bolted to frame.
3. Frame:
   a. Minimum 14-gauge metal construction.
   b. Continuously welded joints.
   c. Reinforced motor baseplate.

C. Propeller:

1. Cast aluminum construction
2. Hub keyed and mechanically locked to shaft .
   .

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground, and polished carbon steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, sealed pillow block style.
   b. .
   c. Mounted in cast iron pillow block housing.
   d. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: Direct.

E. Accessories: Provide as scheduled in Equipment Schedule.

F. Manufacturers and Products:

1. Aerovent; DDP (Direct).
2. Cook; Model AVAD (Direct).
3. Or “Equal”.

2.06 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide integral self-resetting overload protection on single-phase motors.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.
9. Service Factor: 1.15.

2.07 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown on Drawings.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.08 SOURCE QUALITY CONTROL

A. General:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
3. Consider drive efficiency in motor selection according to manufacturer’s published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Acoustical Levels:

1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

D. Balancing: Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Secure roof-mounted fans to roof curbs with Type 316 stainless steel hardware.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Scroll Drains: Pipe drain connection through running trap to floor drain.

E. Labeling:

1. Label fans in accordance with Article Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

F. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

G. Equipment Support and Restraints:

1. Refer to Section 23 05 48, Vibration Isolation and Seismic Control.
2. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.

H. Connections:

1. Refer to Section 23 31 13, Metal Ducts and Accessories.
2. Isolate duct connections to fans.
3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for facility startup.

B. Refer Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

END OF SECTION

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
2. ASTM International (ASTM): C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
3. UL.

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser, register, and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.
2. Samples: Finish color samples.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.02 CEILING DIFFUSERS

A. Premium Louvered Face Diffusers (CD1-X):

1. Construction**:** Refer to Equipment Schedule**.**
2. Removable core section of louvers.
3. Continuous sponge rubber gasket at face flange.
4. Performance: Refer to Equipment Schedule.Manufacturers:
   a. Krueger.
   b. Titus.

B. Perforated Face Diffusers (CD3-X):

1. Construction: Refer to Equipment Schedule.
2. Removable core section with deflector vanes.
3. Removable perforated faceplate.
4. Performance: Refer to Equipment Schedule.
5. Manufacturers:
   a. Krueger
   b. Titus; Model PAS (steel) or PAS-AA (aluminum).

2.03 SUPPLY GRILLES AND REGISTERS

A. Supply Grilles and Registers (SG1-X):

1. Construction: Refer to Equipment Schedule.
2. Adjustable front horizontal and rear vertical vanes on 3/4-inch centers.
3. Continuous sponge rubber gasket at face flange.
4. 1-inch minimum flat rectangular frame.
5. Performance: Refer to Equipment Schedule.Manufacturers and Products:
   a. Krueger; 880/5880 Series.
   b. Titus; 300 Series.

B. Perforated Ceiling Return, Exhaust and Transfer Grilles and Registers (RG2-X:

1. Construction: Refer to Equipment Schedule.
2. Removable perforated faceplate.
3. Size to fit into standard lay-in tee-bar ceiling.

4. Round neck.
5. Manufacturers and Products:
    a. Titus; Model PAR (steel) or PAR-AA (aluminum).
    b. Krueger; Model 6500 Series.
    c. Carnes; Type SPRB (steel) or SLRB (aluminum).

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to architectural reflected ceiling plans for coordination of locations of ceiling-mounted air outlets and inlets with ceiling grids and lighting. Where locations of devices shown on mechanical drawings do not agree with locations that are shown on architectural reflected ceiling plans, reflected ceiling plans shall take precedence. If air outlets or inlets are shown on mechanical drawings, but are not shown on architectural reflected ceiling plans, devices shall be located as near as possible to locations shown on mechanical drawings when coordinating with ceiling.

B. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

C. Provide appropriate frame to adapt to mounting surface. Provide a 24-inch by 24-inch lay-in ceiling module for diffusers, registers, and grilles in lay-in ceilings.

D. Support air inlets and outlets where installed in metal suspension systems for acoustical tile and lay-in panel ceilings as specified in ASTM C636/C636M and applicable building code.

END OF SECTION

SECTION 23 77 00
AIR HANDLING UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
2. Air Movement and Control Association International, Inc. (AMCA):
   a. 201, Fans and Systems.
   b. 203, Field Performance Measurement of Fan Systems.
   c. 204, Balance Quality and Vibration Levels for Fans.
   d. 300, Reverberant Room Method for Sound Testing of Fans.
   e. 301, Methods for Calculating Fan Sound Ratings From Laboratory Test Data.
   f. 99-0401, Classifications for Spark Resistant Construction.
   g. 99-2408, Operating Limits for Centrifugal Fans.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 15, Safety Standard for Refrigeration Systems.
   b. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
   c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   d. 62.1, Ventilation for Acceptable Indoor Air Quality.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. CSA America (CSA):
   a. B149.1, Natural Gas and Propane Installation Code.
   b. Z83.4, Non-Recirculating Direct Gas-Fired Industrial Air Heaters.

c. Z83.18, Recirculating Direct Gas-Fired Industrial Air Heaters.

7. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 841, Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
8. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA):
    a. 54, National Fuel Gas Code.
    b. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
    c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. Occupational Safety and Health Act (OSHA).
12. Society of Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
13. Underwriters Laboratories Inc. (UL):
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 723, Standard for Safety Test for Surface Burning Characteristics of Building Materials.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. ac: alternating current.
2. AFD: Adjustable Frequency Drive.
3. AHU: Air Handling Unit.
4. cfm: cubic feet per minute.
5. dB: Decibel.
6. DX: Direct Expansion.
7. DWDI: Double Width, Double Inlet.
8. ETL: ETL Testing Laboratories, Inc.
9. FM: Factory Mutual Insurance.
10. fpm: feet per minute.
11. hp: Horsepower.
12. MAU: Make-Up Air Unit.
13. NRC: Noise Reduction Coefficient.
14. OD: Outside Diameter.
15. ODP: Open Drip Proof.

16. O&M: Operations and Maintenance.
17. psi: pounds per square inch.
18. PVC: Polyvinyl Chloride.
19. rpm: revolutions per minute.
20. SWSI: Single Width, Single Inlet.
21. TEFC: Totally Enclosed, Fan Cooled.
22. UV: Ultra Violet.
23. VFD: Variable Frequency Drive.
24. WC: Water Column.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawings for products specified, including, as a minimum:
    a. Unit identification as referenced in Contract Documents.
    b. Manufacturer's name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights for unit, including fully assembled and shipping sections.
    e. Acoustics:
        1) Fan sound power level data (ref. 10 to power minus 12 Watts) at design operating point, based on AMCA 300 for unit discharge, inlet and casing.
    f. Fans:
        1) Type, size, quantity, class, drive arrangement, discharge, rotation and bearings.
        2) Wheel type, diameter, rpm, and tip speed.
        3) Performance curves indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum safe operating rpm).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
    g. Unit capacities and ratings, including airflow and static pressure summary.
    h. Power and control wiring diagrams, including terminals and numbers.
    i. Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.

2. "Or Equal" Equipment:
    a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
    b. Where submitted equipment results in change to ductwork and equipment configuration shown on drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance.
3. Sample copy of guarantee.
4. Recommended procedures for protection and handling of products prior to installation.
5. Manufacturer's installation instructions, including component spacing requirements.
6. Operation and Maintenance Data:
    a. In conformance with Section 01 78 23, Operation and Maintenance Data.
    b. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Fans: Licensed to bear AMCA seal for air flow and sound performance.

B. Manufacturer's Qualifications:

1. The make-up unit manufacturer shall have been successfully manufacturing air handling units for a period of no less than 5 years.
2. Manufacturer's qualifications are subject to review by the Owner/Engineer to determine acceptance.

C. Fan Performance:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure.
3. Motor shall not operate into motor service factor in any listed case.
4. Accommodate drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA 203, Appendix L.

D. Thermal Insulation: Shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM E84 and UL 723).

E. Units with Fuel Gas Heating Sections:

1. Conform to CSA Z83.18 and CSA Z83.4 and provide evidence that air handler has been tested as a system and found in compliance with these standards by an independent national testing laboratory.
2. Conform to NFPA 90A.
3. Conform to the NFPA 54.
4. Conform to required or specified insurance specifications (FM, IRI, etc.) for the gas manifold construction.
5. For gas fired units, provide a current sensor on the supply fan motor. When current is outside current sensor limits, the natural gas supply is to be shut down.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Air handling unit manufacturer shall coordinate with the Contractor as to the requirements for proper delivery, storage, and handling of the air handling unit and its components required in this Specification to ensure that the unit is properly cared for prior to final installation.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts**.**

Item	Quantity
V Belts	One complete set per unit
Special tools required to maintain or dismantle	Onecomplete set

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.02 OPERATING LIMITS

A. Fans designated to meet a specified Fan Class shall comply with requirements of AMCA 99-2408.

2.03 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in fan equipment schedule.

B. Perform noise tests in accordance with AMCA 300.

2.04 FAN DRIVES

A. Furnish multiple drive belts.

B. Drive assembly shall be sized for a minimum 150 percent of fan motor horsepower rating.

C. Motors for V-belt drives shall be furnished with adjustable rails or bases.

D. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel fixed sheaves.

E. Motors: Fixed-pitch sheaves required.

F. Drive Adjustment:

1. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
2. Provide trial and final sheaves, as well as drive belts, as required.

G. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.

H. Belt and Shaft Guards:

1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA and State of Tennessee requirements.
2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
3. Bright yellow finish.

I. Provide speed test openings at shaft locations.

2.05 FINISHES

A. Carbon Steel Parts: Factory finished as follows, unless indicated otherwise.

1. Parts cleaned and chemically pretreated with a phosphatizing process.
2. Alkyd enamel primer.
3. Air-dry enamel topcoat.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

2.06 MAKE-UP AIR UNITS—INDUSTRIAL (030-MAU-1)

A. General:

1. Custom air handling unit, constructed by assembly of factory-fabricated components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices and accessories.
2. Required unit components as indicated on plans and equipment schedule.
3. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
4. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

B. Unit Casing:

1. General:
   a. Fully enclosed housing, with casing consisting of sheet metal side, floor and roof panels.
   b. Lifting lugs and unit support frames, factory installed, to facilitate installation.
   c. All casing to consist of formed and reinforced sheet metal panels, insulated as indicated; flat panel design not acceptable.
   d. For double wall units, distance between inner and outer panels as required to accommodate insulation thickness specified in Paragraph, Insulation. Double wall units are required, unless noted otherwise.
2. Panel Arrangement: Panels mechanically fastened together forming a self-framing housing with no additional structural support required.
3. Outdoor Units:
   a. Weathertight and rated for outdoor use.
   b. Cross broken and sloped roof cap system.

c. Drip shield/overhang provided on all four sides of unit.
d. Caulked/sealed standing top seams to assure waterproofing.

4. Material: Panels, fasteners and structural metal frame members constructed from G90 galvanized steel, coated as indicated in" CORROSION PROTECTION" section..
5. Outer Panels:
   a. Outdoor Units:
      1) Walls: Minimum 16-gauge (0.0625 in.) thickness sheet metal.
      2) Roof: Minimum 16-gauge (0.0625 in.) thickness sheet metal.
6. Inner Panels:
   a. Walls and Roof: Minimum 20-gauge (0.0348 in.) thickness sheet metal.
   b. Floor Plate: Minimum 16-gauge (0.0625 in.) thickness sheet metal.
7. Joints:
   a. Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
   b. Seams caulked and sealed for an airtight unit.
   c. Fully through-bolted section to section joints.
8. Insulation:
   a. Single Wall Casing Units:
      1) Insulation secured with steel angles.
      2) Longitudinal insulation joints and butt ends covered by a sheet metal break to prevent erosion of exposed edges.
   b. Double Wall Casing Units: Insulation fully encased between outside and inside panels.
   c. Properties:
      1) 1-inch thickness, 3 pounds per cubic foot density.
      2) Units with Perforated Liner or Exposed Insulation: Black composite protective coating on surface exposed to airstream.
      3) Maximum effective thermal conductivity (C) of 0.24 Btu inch per square foot degrees F.
      4) Minimum NRC of 0.70 per inch thickness.
9. Access Doors:
   a. Heavy-gauge, 0.0625 inch minimum, oversized access doors insulated, double wall construction, internal sheet metal skin.
   b. Sized and located to provide easy access to unit internal components.
   c. Hinged, latched, and gasketed to provide a weatherproof seal.
   d. Provide doors on both side(s) of each unit.

e. Latches:
   1) "Ventlok" style noncorrosive alloy latches operable from inside and outside of unit.
   2) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

10. Casing Performance:
    a. Air Leakage: Maximum of 0.5 cfm per square foot of cabinet area at 5-inch WC static pressure.
    b. Panel Deflection: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection shall not exceed 1/200th of panel length, when subject to 8-inch WC differential pressure.

C. Drain Pans:

1. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
2. Formed sections of minimum 16-gauge (0.0625 in.) Type 304 stainless steel.
3. Triple pitched for complete drainage, with no standing water in unit.
4. Double Wall Construction:
   a. Space between walls filled with foam insulation.
   b. Sealed moisture tight.
   c. Welded corners.
5. Drain Connections:
   a. Type 304 stainless steel, male pipe thread.
   b. Both ends of pan.
   c. Extended to exterior of unit cabinet.
   d. Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.

D. Unit Base:

1. Full perimeter base frame.
2. Minimum10-gauge (0.135 in.) structural steel construction, with C channel cross support members, on close centers.
3. All joints fully welded.
4. Fitted with lifting lugs at corner of unit.
5. Attached to unit at factory, unless noted otherwise for field assembly.

E. Supply Fan Section:

1. General:
   a. Supply air section with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, support structure, and accessories.
   b. Casing constructed in accordance with Article Unit Casing.
   c. Suitable to convey air at temperatures up to 250 degrees F.
   d. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
   e. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.
2. Centrifugal Fan Housing:
   a. Material: G 90 galvanized steel Construction:
      1) Formed and reinforced sheet metal panels, curved scroll configuration with shaped cutoff, continuous seam welding and side angle reinforcement.
      2) Flanged and drilled outlet to permit duct connection.
      3) Spun-formed aerodynamic bell mouth inlet.
      4) Access doors or panels to allow entry to internal parts and components.
      5) Base:
         a) All-welded heavy-gauge metal.
         b) Fan and motor mounted on common base.
         c) Motor Mount: Adjustable slide mount.
   b. Plug Fans: Fabricate without fan scroll and volute housing.
   c. Hardware: Type 316 stainless steel.
3. Fan Wheel:
   a. Centrifugal, one-piece.
   b. Backward Inclined Fans:
      1) DWDI backward inclined fan wheel.
      2) Nonoverloading performance characteristics.
      3) Backward inclined blades, heavy gauge metal construction, continuously welded to backplate and curved inlet flange.
4. Fan Shaft, Bearings, Drive:
   a. Shafts:
      1) Turned, ground, and polished carbon steel.
      2) Ends drilled and countersunk for tachometer readings.
      3) Keyed for sheave installation.
      4) Coated with lubricating oil.

b. Bearings:
   1) Grease lubricated, precision anti-friction ball, self-aligning type.
   2) Mounted in cast iron pillow block housing.
   3) Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
c. Drives:
   1) In accordance with Article Fan Drives.
   2) Factory set to specified fan revolutions per minute.
   3) Type: Belt.
   4) Arrangement: 3.

5. Internal Vibration Isolation:
   a. Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.
   b. Flexible Connectors: Install flexible neoprene coated canvas ducts between fan and unit casing to ensure complete isolation.

F. Gas Heat Section, Direct Fired:

1. General:
   a. Direct-fired fuel gas heating section, fuel type as scheduled.
   b. Casing constructed in accordance with Article Unit Casing.
   c. AGA design certified to CSA Z83.4, for nonrecirculating industrial air heaters.
   d. Entire unit approved and labelled by ETL or other nationally recognized certification agency, for both sea level and high-altitude areas.
   e. Approved for operation down to minus 20 degrees F ambient air.
   f. Visual burner inspection port in unit casing.
   g. Insulation in burner section covered by a heat reflective Type 304 stainless steel liner.
   h. For gas fired units, provide a current sensor on the supply fan motor. When current is outside current sensor limits, the natural gas supply is to be shut down.
2. Pipe Chase:
   a. Piping and piping mounted controls located in pipe chase.
   b. Chase construction and insulation as for unit.
   c. Internal to unit casing.
   d. Adequately sized access door(s) for installation and maintenance of all piping.
3. Gas Pipe Train:
   a. FM Global and IRI code approved.
   b. Housed within unit cabinet.

c. Pipe Train Components:
   1) Flow control valve.
   2) Fail-safe shut off valve(s).
   3) Main and pilot gas pressure regulators.
   4) Manual shut off valves.
   5) Electric pilot valve.
d. Operating Gas Pressure Range, at Unit(s) Manifold: As scheduled.

4. Burner:
   a. Line type.
   b. Housed within unit cabinet.
   c. Constructed in a draw through arrangement; outside air is drawn across the burner section at a constant velocity, within allowable limits of burner design.
   d. Turndown: Minimum 20 to 1.
   e. Combustion Air Openings:
      1) All burner combustion air openings shall be located in Type 430 stainless steel burner plates to maintain design combustion air requirements at all inputs.
      2) Combustion air openings in burner castings are not acceptable due to potential blockage from corrosion.
   f. Gas orifices shall be a maximum of 0.5 inch apart.
   g. Gas burner connection size shall be 1.5 inches minimum in order to assure full turndown performance.
5. Electrical/Controls:
   a. Flame Surveillance: Solid state programmed flame relay complete with flame rod.
   b. Air proving switch.
   c. Control interlocks.
   d. Panelboard: Electrical/control components housed in Unit Main Control Panel; refer to Paragraph Unit Electrical and Controls Panelboard, NEMA Type 4X enclosure, mounted on the outside of unit.

G. Unit Access:

1. Unit access to allow improved access to air handling internal components.
2. Casing constructed in accordance with Article Unit Casing.
3. Double wall, hinged, removable access doors on both side(s) of unit.

H. Filters:

1. General:
   a. Air filtration section, complete with filter media and filter racks.
   b. Casing constructed in accordance with Article Unit Casing.

c. Double wall, hinged, removable access doors on one or both side(s) of unit.
d. Maximum 500 fpm face velocity across filters.

2. Frame and Filter Assembly:
   a. Suitable for space indicated.
      1) MERV 8 efficiency per ASHRAE 52.2.
      2) Minimum 30 percent Dust Spot Efficiency and 90 percent average arrestance in accordance with ASHRAE 52.
   b. Permanent reusable, side-loading aluminum holding frame, retainer, and sealer frame.
   c. Filter blank-offs to prevent air bypass around filters, same material as frame.
   d. For 100 percent make-up air application, each individual filter to include minimum 18-gauge galvanized steel full perimeter frame on each individual filter for later strength if filter becomes damp.
3. Accessories:
   a. Filter Pressure Gauge:
      1) Each filter bank shall be furnished with Magnehelic filter gauge (Dwyer Series 2000).
      2) Adjustable signal flag.
4. Manufacturers:
   a. Farr.
   b. Flanders.
   c. Tri-Dim.
   d. American Air Filter.

I. Outside Air Intake:

1. Weather Hood: Fully welded construction, fabricated from same material as unit casing.
2. Louver: Drainable type, S-shaped rainproof blades, spaced 2 inches maximum.
3. 1/2-inch mesh PVC-coated galvanized bird screen on inside face of louver.

J. Control Dampers:

1. Internally mounted ultra-low leak dampers.
2. Parallel blade action.
3. Construction:
   a. Extruded aluminum blades.
   b. Galvanized steel frame, U-shaped galvanized metal sections securely screwed or welded to unit chassis.
   c. Vinyl blade seals, stainless steel jam seals.

d. Type 304 stainless steel linkage, shafts, and hardware.
e. Type 304 stainless steel sleeve bearings.

4. Performance: Leakage rate shall not exceed 5 cfm per square foot at 1 inch-WC and 9 cfm per square foot at 4-inch WC.

K. Unit Electrical and Controls:

1. General:
   a. Electrical and control components shall meet requirements of Division 26 Electrical.
   b. All electrical and controls components and assemblies UL or ETL listed and labeled.
   c. Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
   d. Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
   e. For additional requirements, refer to Specification paragraphs for individual sections and components, and Section 23 09 00, Instrumentation and Control Devices for HVAC.

2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.

L. Accessories: Provide where scheduled in Equipment Schedule.

M. Manufacturers and Products:

1. Aerovent; BT.
2. Reznor; RHH.
3. Logic Air; LMU.
4. Rapid Engineering; Series 8000.

2.07 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide integral self-resetting overload protection on single-phase motors. Provide IEEE 841 motor, unless noted otherwise.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Fan motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows unless designated otherwise on fan equipment schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.

2.08 CORROSION PROTECTION

A. General:

1. Factory applied corrosion protection coating for application to unit components and accessories, where in required by this Section.
2. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning: For all coating systems, parts to be coated shall be cleaned as follows:
   a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
   c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Air Dry Phenolic:

1. Material:
   a. Phenolic resin, Heresite VR-500 Series.
   b. For outdoor applications, apply UV-resistant topcoat, Heresite UC-5500.
2. Surface Preparation: Sandblast surface to SSPC-SP 6.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4-mil to 6-mil dry film thickness.

6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 500-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 500-hour duration, ASTM D2247 test method.
    c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Tennessee.
    d. Service Temperature: Maximum 180 degrees F, continuous.

2.09 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated as shown.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.10 SOURCE QUALITY CONTROL

A. Factory Tests and Adjustments Test equipment actually furnished.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Manufacturer’s Tests:

1. Electrical Circuits:
    a. Tested and checked as to proper function.
    b. Perform dielectric strength test.

D. Balancing:

1. Completed fan assemblies shall be dynamically balanced to minimum grade of G 6.3 per AMCA 204 at design operating speed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Secure roof-mounted units to rood curbs with Type 316 stainless steel hardware.

C. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

D. All condensate drain connections piped and trapped separately for proper drainage.

E. Labeling: In accordance with Article Accessories.

F. Service Access: Locate units to provide access spaces required for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

G. Equipment Restraints:

1. Restrain equipment against seismic forces as required by Code.
2. Restrain equipment against wind loads as required by Code.
3. Refer Section 23 05 48, Vibration Isolation and Seismic Control.
4. Seismic Restraint Snubbers:
    a. Rubber-faced, securely anchored to floor or structure.
    b. Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.

H. Connections:

1. Isolate sheet metal duct connections from all noninternally spring-isolated fan units or other rotating equipment.
2. Install ductwork adjacent to fans so as to allow proper service and maintenance.
3. Pipe drain pan connection through trap running to floor drain.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify shipping blocking and bracing are removed.
2. Verify unit is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters and disconnect switches.

4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system, align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated rpm.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate non-sealed bearings prior to startup.

D. Air Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

3.04 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative: Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance and inspection.
2. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for facility startup.

END OF SECTION

SECTION 23 81 00
UNITARY AIR-CONDITIONING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. Air Moving and Conditioning Association (AMCA): Bulletin 300, Setup No. 1.
3. American Gas Association (AGA).
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   b. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
5. American Society of Mechanical Engineers (ASME): BPVC Section IX, Welding and Brazing Qualifications.
6. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2370, Standard Test Method for Tensile Properties of Organic Coatings.
   c. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   d. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   e. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
7. Canadian Standards Association (CSA).
8. ETL Testing Laboratories (ETL).
9. International Organization for Standardization (ISO):
   a. 9001, Quality Management Systems - Requirements.
   b. 13256-1, Water-Source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-Air and Brine-to-Air Heat Pumps.
10. National Electrical Manufacturers Association (NEMA).
11. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
12. Underwriters Laboratories Inc. (UL): 94, Safety Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Air Conditioning.
2. COP: Coefficient of Performance.
3. DX: Direct Expansion.
4. EER: Energy Efficiency Ratio.
5. HP: Heat Pump.
6. IR: Infra Red.
7. LED: Light Emitting Diode.
8. PSC: Permanent Split Capacitor.
9. PTAC: Packaged Terminal Air Conditioner.
10. SPST: Single Pole, Single Throw.
11. TXV: Thermostatic Expansion Valve.
12. UV: Ultraviolet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
   b. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for all products specified.
   c. Manufacturer’s standard finish color selection for enclosure finishes.
   d. Complete performance data that will indicate full compliance with Specification:
      1) Include fan sound power level data (ref. 10 to 12 watts) at design operating point, based on AMCA Bulletin 300, Setup No. 1.
      2) Include heating and cooling performance data at design operating conditions.
   e. Factory dip-applied protective coating product data.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s Certificate of Compliance, for heat pumps, air-conditioning units, and motors.

3. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
4. Sample copy of guarantee.
5. Test reports.
6. Operation and Maintenance Data in conformance with Section 01 78 23, Operation and Maintenance Data.
    a. Include wiring and control diagrams for equipment.
    b. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in ASHRAE 90.1.

B. Unit shall be rated (when matched with appropriate outdoor unit) per AHRI 210/240.

C. Units shall be certified by UL and CSA, and shall be UL or ETL listed and labeled.

D. Cooling performance rated in accordance with AHRI testing procedures.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

B. Protection of Equipment:

1. Box, crate, or otherwise protect from damage and moisture during shipment, handling, and storage.
2. Protect from exposure to corrosive fumes and keep thoroughly dry at all times.
3. Store motors, drives, electrical equipment, and other equipment with antifriction or sleeve bearings in weathertight and heated storage facilities prior to installation.
4. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

1.06 SPECIAL GUARANTEE

A. Refrigerant Compressors: Furnish manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of Owner, removal and replacement of compressors specified in this Specification found

defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.07 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following materials:

Item	Quantity
Fan Belts	One complete set for each belt-driven fan.
Filters	One complete set per unit.

PART 2 PRODUCTS

2.01 GENERAL

A. Specified components of this section, including insulation, facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Multiple Compressor Units:

1. Provide completely independent refrigeration circuits and controls.
2. Indoor unit air coils shall have intermingled circuits, unless specified otherwise.

2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 SPLIT SYSTEM AC INDOOR UNIT, DUCTED (UP TO 5 NOMINAL TONS)

A. General:

1. Indoor mounted, draw-through, packaged air-handling unit consisting of forward-curved centrifugal fan(s), motor and drive assembly, prewired fan motor contactor, factory-installed refrigerant metering devices, cooling coil, disposable air filters, and condensate drain pan.
2. Suitable for use with air conditioner or heat pump outdoor unit.
3. Indoor unit shall be of the same manufacturer as the associated outdoor unit.
4. Modular design vertical upflow, field convertible for vertical downflow, or horizontal flow.

B. Unit Cabinet:

1. Heavy gauge galvanized steel sheets.
2. Phosphatized and factory finished in manufacturer's standard enamel paint.
3. Sufficient removable panels for access to all internal components.
4. Interior of casing insulated with 1-inch, 1-pound density coated glass fiber insulation attached with adhesive material.
5. Duct flanges for connection of supply and return ductwork, and filter racks.
6. Knockouts for unit electrical power and condensate piping connections.

C. DX Evaporator Coil:

1. Copper tube with aluminum fins and galvanized steel tube sheets.
2. Fins bonded to tubes by mechanical expansion.
3. Condensate Drain Pan: High-impact thermoplastic, insulated, sloped in two planes, with primary and secondary brass drain fittings.
4. Refrigerant piping sweat connections.
5. Coat entire coil with anticorrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

D. Gas Heating Section:

1. AGA certified.
2. Gas-fired furnace with aluminized steel heat exchanger and burners.
3. Power vent.
4. Manual shutoff valve.
5. Automatic gas valve.
6. Electronic ignition.
7. Suitable for use on natural gas with a heating value of 1,000 Btu/cubic foot supplied at 7 inches of water column gas pressure.
8. Double-inlet, double-width, forward-curved fan mounted on rubber isolators.
9. Direct-drive or belt-drive as standard with the unit furnished.
10. Fan Motor:
    a. Totally enclosed and permanently lubricated with inherent protection.
    b. Three-speed.

E. Controls:

1. Refrigerant Metering: Factory installed refrigerant metering device.
2. Magnetic contactor for fan.
3. Overload protection in each leg.
4. Control voltage transformer.

5. Terminal strip for connection of remote controls.
6. Control board fusing.

F. Air Filters: Disposable 2-inch-thick strainer type with pleated nonwoven fabric media.

G. Accessories: Provide as scheduled in Equipment Schedule.

H. Manufacturers:

1. Carrier.
2. Trane.
3. Rheem.
4. Lennox International.
5. York Air Conditioning.

2.04 SPLIT SYSTEM AC INDOOR UNIT, DUCTED (OVER 5 NOMINAL TONS)

A. General:

1. Indoor-mounted, draw-through, packaged air-handling unit consisting of forward-curved belt-driven centrifugal fan(s), motor and drive assembly, prewired fan motor contactor, factory-installed refrigerant metering devices, cooling coil, disposable air filters, and condensate drain pan for vertical or horizontal configurations.
2. Suitable for use with air conditioner or heat pump outdoor unit.
3. Indoor unit shall be of the same manufacturer as the associated outdoor unit.
4. Modular design vertical upflow, field convertible for vertical downflow, or horizontal flow.

B. Unit Cabinet:

1. Heavy gauge galvanized steel sheets.
2. Phosphatized and factory finished in manufacturer’s standard enamel paint.
3. Sufficient removable panels for access to all internal components.
4. Interior of casing insulated with 1-inch, 1-pound density, coated foil-faced glass fiber insulation attached with adhesive material.
5. Duct flanges for connection of supply and return ductwork, and filter racks.
6. Knockouts for unit electrical power and condensate piping connections.

C. Evaporator Fan:

1. Double-inlet, double-width, forward-curved fans mounted on rubber isolators.
2. Belt-drive.

D. DX Evaporator Coil:

1. Minimum three-row configuration, copper tube with aluminum fins and galvanized steel tube sheets.
2. Fins bonded to tubes by mechanical expansion.
3. Refrigerant piping sweat connections.
4. Condensate Drain Pan:
   a. High-impact thermoplastic, insulated, with primary and secondary brass drain fittings.
   b. Double sloped to prevent standing water from accumulating.

E. Electric Heating Coil:

1. UL listed.
2. Heavy-duty nickel-chromium elements.
3. Contactors with 24-volt coils, power wiring, 24-volt control wiring terminal blocks, and a hinged access panel.
4. Individual line-break HIGH limit control for each stage.
5. HIGH limit control operating through heating element contactors, equipped with automatic reset.
6. Internally factory-wired to provide single-point power connection with unit.

F. Controls:

1. Refrigerant Metering:
   a. Factory installed TXV for refrigerant control.
   b. TXV shall be capable of external adjustment.
   c. Heat Pump Applications: Reverse flow bypass TXV with internal check valves.
2. Magnetic contactor for fan.
3. Overload protection in each leg.
4. Control voltage transformer.
5. Terminal strip for connection of remote controls.
6. Control board fusing.

G. Air Filters:

1. Disposable 2-inch thick with pleated nonwoven fabric media.
2. Filter access from either the right or left side of the unit.

H. Accessories: Provide as scheduled in Equipment Schedule.

I. Manufacturers:

1. Carrier.
2. Lennox International.
3. Rheem.
4. Trane.
5. York Air Conditioning.

2.05 SPLIT SYSTEM AC OUTDOOR UNITS

A. General:

1. Factory assembled, single piece, air-cooled air conditioner outdoor unit.
2. Contained within the unit enclosure shall be factory wiring, piping, controls, compressor, and holding charge of R-410 refrigerant.
3. Outdoor unit shall be same manufacturer as associated indoor unit.

B. Unit Cabinet:

1. Constructed of galvanized steel, phosphatized and coated with a baked enamel finish. Finish shall pass the 500-hour salt spray test.
2. Removable access panels for access to internal components.
3. Outdoor Compartment: Isolated, with acoustic lining to ensure quiet operation.
4. Knockouts for unit electrical power.

C. Condenser Fans:

1. Direct-drive propeller type shall discharge air vertically and shall blow air through outdoor coil.
2. Motors:
   a. Totally enclosed, with Class B insulation and permanently lubricated bearings.
   b. Thermal overload protection.
3. Shaft of galvanized or stainless steel construction.
4. Fan blades shall be corrosion-resistant and be statically and dynamically balanced.
5. Equip openings with PVC-coated protection grille over fan and coil.

D. Compressor:

1. Fully hermetic reciprocating or scroll type.
2. Equipped with oil system, operating oil charge, and motor.

3. Internal overloads shall protect compressor from overtemperature and overcurrent.
4. Motor: NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
5. Scroll compressors shall have high discharge gas temperature protection.
6. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.
7. Installed on rubber vibration isolators and shall have internal spring isolation.

E. Condenser Coil:

1. Constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes that are cleaned, dehydrated, and sealed.
2. Coat entire coil with anticorrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

F. Refrigeration Components:

1. Brass external liquid line service valve with service gauge port connections.
2. Suction line service valve with service gauge connection port.
3. Service gauge port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps.
4. Suction Line: Accumulator.
5. Pressure relief.

G. Controls:

1. Factory selected, assembled, and tested.
2. Refrigerant Metering:
   a. Reversing valve for heat pump units.
   b. Heating mode metering device for heat pump units.
3. Automatic restart on power failure.
4. Three-pole contactors.
5. Time delay control sequence shall be provided standard through control board on indoor units.
6. High pressure and liquid line low pressure switches.
7. Automatic outdoor fan motor protection.
8. Start capacitor and relay (single-phase units without scroll compressors).
9. Defrost board to provide defrost control.

10. Safeties:
    a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
    b. Safety lockout if an outdoor unit safety is open.
    c. High condensing temperature protection.
    d. System diagnostics.
    e. Compressor motor current and temperature overload protection.
    f. High pressure relief.
    g. Outdoor fan failure protection.

H. Accessories: Provide as scheduled in Equipment Schedule.

I. Manufacturers:

1. Carrier.
2. Trane.
3. Rheem.
4. Lennox International.
5. Addison.
6. Mitsubishi.
7. York Air Conditioning.

2.06 FACTORY DIP-APPLIED PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable. If protective coating is applied to coil after factory assembly of equipment, cost for shipping unit to coating factory, disassembly, coating process, reassembly, and delivery to Site shall be borne by Contractor.

B. Coating Material: Use one of the following materials:

1. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Completed remove coil from equipment during coating application.
   c. Spray-on coatings are not acceptable.
4. Curing: Oven baked at metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks and blisters.

D. Performance: Coil finish shall meet or exceed the following criteria:

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
2. Thermal Efficiency: Loss no greater than 1 percent after coating application.
3. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.
3. Bronzglow; F-875.

2.07 ELECTRICAL

A. General:

1. Units shall include high and low voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters/Contactors: Factory installed with unitary equipment, unless otherwise noted.
4. Disconnects: Factory installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Refer to Section 26 20 00, Low-Voltage AC Induction Motors, for general requirements.
2. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer's standard.
   e. Space Heater: Manufacturer's standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer's standard.
   g. Efficiency: Minimum efficiency per Section 26 20 00, Low-Voltage AC Induction Motors.

2.08 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch-high engraved block type black enamel filled equipment identification number and letters indicated in this Specification.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications. Quantity as recommended by manufacturer.

2.09 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Direct expansion coils leak tested underwater with 200-psig air. Pressure tested to 450 psig.
2. Electric heating coils tested with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with manufacturer's recommendations, and these Specifications.
2. Set and install equipment so equipment is level and properly supported.
3. Ensure piping connections to equipment do not cause strain on equipment.
4. Ensure vibration isolation has been installed per manufacturer's instructions and isolation devices are performing satisfactorily.
5. Install safety devices as recommended by manufacturer and required by code.

B. Isolate sheet metal duct connections from portions of unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

C. Inspect internal casing insulation, seal exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

D. Filters:

1. Install set of filters in each unit before operating and leave in place during startup and testing to keep equipment and ductwork clean.
2. Do not operate units until filters are installed. If operated without filters, completely clean ductwork, coils, and interior of units.

E. Lubricate unsealed bearings prior to startup.

3.02 FIELD QUALITY CONTROL

A. Initial equipment testing and startup shall be made by authorized representative of unit manufacturer.

B. Air-cooled outdoor unit shall not be started without complete prestart checkout of entire refrigerant piping system and charging of system with refrigerant as recommended by equipment manufacturer.

C. Field Testing: Manufacturer shall provide factory-trained representative employed by equipment manufacturer to perform the following services. Supervision only, of Contractor personnel, will not be acceptable.

1. Leak test.
2. Refrigerant pressure test.

3. Evacuate (if required).
4. Dehydrate (if required).
5. Charge condensing unit with refrigerant and oil (if required).

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for the following:

1. Inspect installation including external interlock, power connections; supervise initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.
2. Test Report:
   a. Submit test reports unit is in safe and proper operating condition.
   b. Contain pressure and control settings, meg readings, voltage readings per phase during START and RUN, suction temperature and pressure, liquid temperature and pressure.
   c. List minor discrepancies to be corrected which do not affect safe and reliable operation.
   d. One copy of report shall be left in unit control panel.
3. One copy of bound installation operation and maintenance service, and parts brochures, including applicable serial numbers, full unit description, parts ordering sources, shall be placed in unit control panel at time of starting.
4. Training of Owner's personnel for specified equipment.

3.04 ADJUSTING AND CLEANING

A. Air System Balancing: As specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Install set of filters at time of final cleaning as defined in Section 01 77 00, Closeout Procedures.

END OF SECTION

SECTION 23 82 00
TERMINAL HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association (AMCA): 300, Reverberant Room Method for Sound Testing of Fans
2. American Gas Association (AGA).
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 90.1 IP/SI, Energy Standard for Buildings, Except Low-Rise Residential Buildings.
4. ASTM International (ASTM):
   a. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   b. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
5. Canadian Gas Association (CGA).
6. Electrical Test Laboratories (ETL).
7. National Electrical Manufacturer's Association (NEMA).
8. National Fire Protection Association (NFPA):
   a. 54, National Fuel Gas Code.
   b. 70, National Electrical Code (NEC).
   c. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
9. Sheet Metal and Air Conditioning Contractors' National Assoc., Inc. (SMACNA): Ducted Electric Heat Guide for Air Handling Systems.
10. UL: Product Directories.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. hp: Horsepower.
7. ODP: Open Drip Proof.
8. PSC: Permanent Split Capacitor.
9. SWSI: Single Width, Single Inlet.

10. TEFC: Totally Enclosed, Fan Cooled.
11. UV: Ultraviolet.
12. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
2. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for products specified.
3. Manufacturer's standard finish color selection for cabinet finishes.
4. Performance data, including sound power level data (reference 10 to minus 12 power watts) at design operating point, shall be based on AMCA 300.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's test reports for the following:
   a. Gas Duct heater.
   b. Electric space heater.
3. Recommended procedures for protection and handling of equipment and materials prior to installation.
4. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the equipment furnished.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Heating Equipment: Minimum operating efficiencies, specified in Chapter 6 of ASHRAE 90.1 IP/SI and the State of Tennessee Energy Code.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Equipment Schedules: Refer to Drawings.

2.02 UNIT HEATER, ELECTRIC, SUSPENDED

A. Characteristics:

1. Factory assembled including casing, heater elements, fan wheel, drive assembly, motor, controls and accessories.
2. UL listed.
3. Meet requirements of National Electrical Code.
4. Three phase heaters shall have balanced phases.
5. Casing:
   a. Heavy gauge steel casing.
   b. Baked enamel finish.
   c. Individual adjustable discharge louvers.
   d. Protective air inlet louvers or fan guards.
6. Heating elements shall be one of the following types:
   a. Aluminum finned, copper clad, steel sheath.
   b. High mass, all steel tubular finned type, copper brazed, in fixed element banks.
   c. Nickel-chromium wire elements enclosed in powder filled aluminum coated steel tubes with permanently fused fins.
   d. Steel tubes with nickel chromium resistance wire embedded in a dielectric with steel fins crimped and brazed to the tube.
   e. Corrosion-resistant steel fins brazed to tubular heating elements.
7. Fan and Motor:
   a. Totally enclosed motor.
   b. Direct drive fan.
   c. Sealed bearings. Permanently lubricated.
8. Controls:
   a. Thermal overload protection with automatic reset.
   b. Controls, transformers, and contactors shall be factory assembled, except wall mounted thermostats when indicated.

B. Accessories and Features: Provide as scheduled in Equipment Schedule.

C. Manufacturers and Products:

1. Qmark; Type MUH.
2. Trane; Type UHEC.
3. Modine: Type HER (horizontal discharge).
4. Markel; Series 5100.
5. Chromolox; Series LUH (horizontal discharge).

2.03 DUCT HEATER, GAS, INDIRECT

A. Characteristics:

1. Factory-assembled, duct mounted, separated combustion, gas-fired duct furnace, for indoor applications, including housing, burner, heat exchanger, vent blower and motor, controls and accessories.
2. Approved for installation downstream of air-conditioning coil.
3. Designed and manufactured in accordance with ANSI definition of "separate combustion."
4. Design-certified by AGA and approved by CGA.
5. Display AGA label.
6. ETL or UL Listed.
7. Manufacturer must have a minimum of 6 years' experience with gas-fired unit heaters using separated combustion techniques.
8. Cabinet:
   a. Galvanized or aluminized steel cabinet with baked enamel finish.
   b. Side access for burners with fully gasketed doors.
   c. Separate electrical, venting and gas control access, with fully gasketed doors.
   d. Inlet and outlet flanges for duct connections. Type 409 stainless steel bottom drip pan and drain connection.
9. Combustion Air/Venting:
   a. Power vent blower and motor with stainless steel shaft.
   b. Vertical combustion air inlet/vent terminal assembly.
10. Burner:
    a. Equipped with orifices for use with natural gas.
    b. Material: Aluminized burners with stainless steel insert.
    c. Gas Train: Regulated combination redundant gas valve consisting of combination pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shut-off, and manual shut-off, all in one body.
    d. Electronic modulated gas controls.
    e. Slide-out burner drawer.
11. Heat Exchanger:
    a. Material: Aluminized steel.
    b. Minimum Efficiency: 80 percent.
    c. Provide "finger baffles" for proper air distribution at lower air flows.
    d. Provide flared ports (burner air shutters).
12. Controls and Safeties:
    a. Operating and safety controls required by UL and NEC.
    b. Prewired and self-contained.
    c. Spark-ignited intermittent safety pilot with continuous retry control system.

d. Electronic flame supervision.
e. Timed lockout.
f. High limit safety cutout, manual reset.
g. High and low gas pressure switches.
h. Prepurge and post-purge control sequence.
i. Combustion air pressure differential switch to verify proper vent flow before allowing the gas valve to function; adjustable.

13. Electrical:
    a. Separate line voltage and control voltage terminal strips.
    b. 24-volt control voltage transformer.

B. Accessories: Provide as scheduled in Equipment Schedule.

C. Manufacturers and Products:

1. Reznor; Model SC Series 6.
2. Modine; Model DFS.

2.04 GAS VENT STACKS

A. Characteristics:

1. Suitable for gas-fired unit heaters.
2. UL listed Type B or PS double wall, insulated gas vent pipe with rain cap.
3. Galvanized steel outer jacket, aluminum inner sleeve.
4. Insulating thimble.
5. Pier section with cleanout where stack is offset.
6. Manufacturer’s standard fittings as required.

B. Manufacturers and Products:

1. Selkirk; Metalbestos.
2. Van Packer.

2.05 ELECTRICAL

A. General:

1. Units shall include high and low voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters/Contactors: Factory installed with unitary equipment, unless otherwise noted.
4. Disconnects: Factory installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Refer to Section 26 20 00, Low-Voltage AC Induction Motors, for general requirements.
2. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer's standard.
   e. Space Heater: Manufacturer's standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer's standard.
   g. Efficiency: Minimum efficiency per Section 26 20 00, Low-Voltage AC Induction Motors.

2.06 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.07 SOURCE QUALITY CONTROL

A. Functional Test:

1. Perform manufacturer's standard factory test on equipment.
2. Test equipment furnished.
3. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.
4. Equipment with Electric Resistance Heating Coils: Test with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install in strict compliance with manufacturer's instructions. Maintain clearances around unit as listed in manufacturer's recommendations.

B. Electric Unit Heaters, All Types:

1. Bottom of unit shall be a minimum of 8 feet above finish floor, unless indicated otherwise.
2. Heater shall be permanently mounted in position indicated with a fixed power supply.
3. Install so obstructions do not block heater air inlet or outlet.

C. Gas Vent Stacks: Install in accordance with requirements of NFPA 54.

3.02 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

END OF SECTION

SECTION 23 84 00
HUMIDITY CONTROL EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
2. Air Moving and Conditioning Association (AMCA): 300, Reverberant Room Method for Sound Testing of Fans.
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
   b. 84, Method of Testing Air-to-Air Heat Exchangers.
   c. 90.1 IP/SI, Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
   c. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning Plastics in a Horizontal Position.
   d. D2370, Standard Test Method for Tensile of Organic Coatings.
   e. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
5. Canadian Standards Association (CSA).
6. Electrical Test Laboratories (ETL).
7. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
8. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 255, Standard Method of Test for Surface Burning Characteristics of Building Materials.

9. Nationally Recognized Testing Laboratories (NRTL).
10. Underwriters Laboratories Inc. (UL): 1995, UL Standard for Safety Heating and Cooling Equipment.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Air Conditioning.
2. COP: Coefficient of Performance.
3. DX: Direct Expansion.
4. EER: Energy Efficiency Ratio.
5. HP: Heat Pump.
6. IR: Infrared.
7. LED: Light Emitting Diode.
8. OSA: Outside Air.
9. PSC: Permanent Split Capacitor.
10. PTAC: Packaged Terminal Air Conditioner.
11. SPST: Single Pole, Single Throw.
12. TXV: Thermostatic Expansion Valve.
13. UV: Ultraviolet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
2. Specifications, descriptive drawings, catalog cuts, and descriptive literature; include make, model, dimensions, weight of products, and electrical schematics, for products specified.
3. Complete performance data that indicates full compliance with Specifications:
    a. Include fan sound power level data (ref. 10 watts to 12 watts) at design operating point, based on AMCA 300, Setup No. 1.
    b. Include heating and cooling performance data at design operating conditions.
    c. Factory dip applied protective coating product data.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s Certificate of Compliance.

3. Recommended procedures for protection and handling of equipment and materials prior to installation.
4. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to equipment furnished.
5. Operation and maintenance data as specified in Section 01 78 23, Operation and Maintenance Data.
6. Special guarantees.

1.04 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as Coefficient of Performance (COP) and Energy Efficiency Ratio (EER), specified in Chapter 6 of ASHRAE 90.1 IP/SI.

1.05 SPECIAL GUARANTEE

A. Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee.

B. Special guarantee shall provide for correction, or at the option of Owner, removal and replacement of the Work specified in this Specification found defective during a period of 5 years after date of Substantial Completion.

C. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

Item	Quantity
Filters	Four complete sets per unit

PART 2 PRODUCTS

2.01 GENERAL

A. Specified components of this section, including insulation, facings, mastics, and adhesives shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 DEHUMIDIFIER, INDOOR UNIT, SPLIT SYSTEM DX 100 PERCENT OSA

A. General:

1. Designed to conform to ETL or CSA.
2. Coils shall be UL or CSA listed.
3. Fan motor shall be UL or CSA listed.
4. Units shall be completely factory assembled, wired, and fully tested in all modes of operation.
5. Controls shall be factory adjusted and preset to the design conditions.
6. Test report shall be available on request. Engineer reserves the right to witness factory performance testing.
7. Manufacturer shall have a minimum of 5 years' experience in the production of dehumidification systems.

B. Cabinet:

1. Constructed of G-90 galvanized steel with minimum gauge thickness of:
   a. Base: 16 gauge (0.0625 in.).
   b. Corner Posts and Tops: 18 gauge (0.0475 in.).
   c. Access Panels: 20 gauge (0.0348 in).
2. Interior shall be thermally insulated with 1-inch-thick fiberglass with R-value of 4.2.
3. Mounted on two steel rails to facilitate installation.
4. Paint entire cabinet internally and externally, as detailed below.

C. Base:

1. Unit base pan shall be poured with minimum 1/4-inch hot asphalt (tar) to prevent rain or condensate from contacting steel on bottom of base pan.
2. Asphalt shall be poured prior to final factory assembly to assure protection of steel areas.

D. Paint Finish:

1. Thoroughly clean exterior parts chemically, zinc-phosphate coat, and seal with chromic rinse.
2. Electrically deposited by immersion dipping in a cationic electro-deposition paint system.
3. Baked for a minimum of 20 minutes at 400 degrees F.

4. Minimum paint film thickness of 1 mil.
5. Finish shall meet or exceed a 1,000-hour salt spray test per ASTM B117.

E. Hardware:

1. Exterior Nuts, Bolts, and Washers: Zinc electroplated carbon steel
2. Exterior Screws: Zinc electroplated carbon steel.

F. Compressor:

1. Hermetic type, scroll type suction gas cooled, suitable for refrigerant R-410A, equipped with internal thermal protection, and resilient type external mounting.
2. Compressor manufacturer shall have a wholesale outlet for replacement parts in the nearest major city.
3. Warranty: 5 years.

G. Evaporator Coil:

1. Aluminum plate-finned formed on multiple rows of seamless copper tubing arranged in a staggered tube configuration.
2. Tubes shall be mechanically expanded, firmly bonding tube to shoulder of each fin.
3. Coat entire coil with anticorrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

H. Hot Gas Reheat Coil:

1. Designed to reheat air leaving evaporator coil.
2. Factory installed and tested. Field installed reheat coil shall not be acceptable.
3. Fabricated from seamless copper tubing mechanically expanded to assure high heat transfer with maximum 12 aluminum fins per inch.
4. Coat entire coil with anti-corrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

I. Drain Pan:

1. Fabricated from G-90 galvanized steel, painted in electro-deposition paint system, and overcoated with a corrosion and moisture resistant film barrier that meets or exceeds a 6,000-hour salt spray test, per ASTM B117.
2. Bottom of condensate drain shall be insulated with 1-inch fiberglass insulation.
3. Furnish with single or dual 3/4-inch FTP drain fittings positioned at exterior of cabinet.

J. Evaporator Fan and Motor:

1. A forward curved, statically and dynamically balanced DIDW centrifugal fan shall be used for evaporator air.
2. Fan Wheels:
   a. Fabricate of galvanized or galvalume steel.
   b. Mount on a solid steel shaft supported by sealed ball bearings.
3. Fan Housing: Fabricate of epoxy coated steel.
4. Shaft: Driven by adjustable belt drive fixed pitch sheaves connected to a 1,725 rpm motor with sealed ball bearings.
5. Sealed bearings on fan and motor shall not require lubrication.

K. Refrigerant Circuit: Include high latent heat evaporator coil and thermal expansion valve.

L. Controls:

1. Unit controller with LCD display and enough I/O to control exhaust fans 050-EF-1, 050-EF-2 and gas duct heater 050-GDH-1.
2. Include fan motor contactors or starters with thermal protection (auto-reset) on inductive loads.
3. The 24-volt control circuit shall include a 75VA rated transformer.

M. Filters: 2-inch disposable type.

N. Accessories: Provide as scheduled in Equipment Schedule.

O. Manufacturers:

1. Desert Aire.
2. AAON.

2.04 OUTDOOR UNIT, AIR-COOLED CONDENSER

A. General:

1. Match with associated indoor unit.
2. Direct drive propeller fan.
3. Aluminum condenser with copper tubes and aluminum fins.
4. Arrange for vertical air discharge.
5. Suitable for pad mounting.

B. Variable Speed Motor:

1. Operate from 0V ac to 230V ac, single-phase.
2. Permanently lubricated ball bearings.

3. Internal overload protection.
4. 40 degrees C rise at full speed, 65 degrees C rise at low speed.

C. Condenser Coil:

1. Aluminum plate fins formed on multiple rows of seamless copper tubing arranged in a staggered tube configuration.
2. Tubes shall be mechanically expanded, firmly bonding tube to shoulder of each fin.
3. Coat coil with anticorrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

D. Controls:

1. Complete with transducers, thermostats, and electrical control circuit factory prewired in control panel.
2. Variable speed fan to operate in response to head pressure transducer to allow compressor operation down to minus 20 degrees F.
3. Solid state winter start kit to be an integral feature of electronic control panel.

E. Manufacturers:

1. AAON.
2. Desert Aire.

2.05 FACTORY DIP-APPLIED PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable. If protective coating is applied to coil after factory assembly of equipment, cost for shipping unit to coating factory, disassembly, coating process, reassembly, and delivery to Site shall be borne by Contractor.

B. Use one of the following coating materials:

1. Epoxy modified phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy-urethane.
3. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Coil shall be completely removed from equipment during coating application.
   c. Spray-on coatings are not acceptable.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks and blisters.

D. Coil finish shall meet or exceed the following criteria:

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
2. Thermal Efficiency: Loss no greater than 1 percent after coating application.
3. UV inhibited life of minimum 10 years when exposed to sun in the State of Tennessee.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.
3. Bronzglow; Husky® Coil Coat.

2.06 ELECTRICAL

A. General:

1. Units shall include high and low voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters/Contactors: Factory installed with equipment, unless otherwise noted.
4. Disconnects: Factory installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Refer to Section 26 20 00, Low-Voltage AC Induction Motors, for general requirements.
2. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer’s standard.
   e. Space Heater: Manufacturer’s standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer’s standard.
   g. Motor Efficiency: Premium efficient.
   h. Shaft Type: Solid, carbon steel.
   i. Mounting: As required for fan arrangement.
   j. Service Factor: 1.15.

2.07 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown on the Drawings.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

PART 3 EXECUTION

3.01 INSTALLATION

A. Filters:

1. Install a complete set of filters in each unit before operating, and leave in place during startup and testing to keep equipment and ductwork clean.
2. Install a complete set of clean filters at the time of final cleaning as defined in Section 01 77 00, Closeout Procedures.

3.02 ADJUSTING AND CLEANING

A. Air System Balancing: As specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Air Handlers:

1. Lubricate nonsealed bearings prior to startup.
2. Do not operate units until filters are installed. If operated without filters, completely clean coils and interior of units.

C. Vibration:

1. Statically and dynamically balance fan equipment.
2. Perform field testing on rotating equipment, as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
3. If vibration limits described therein are exceeded, rebalance equipment in-place, if directed by Engineer, until design tolerances are met.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

B. Dehumidification manufacturer's representative shall conduct a performance test on the dehumidification unit.

1. Perform under active and approval simulated operating conditions.
2. Test for a continuous 3-hour period without malfunction.
3. Test Log: Upon completion of test, record, and report results.
4. Adjust or modify units as necessary and retest.
5. Submit results to Engineer.

END OF SECTION

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): 1584, Guide for Performing Arc-Flash Calculations.
2. National Electrical Contractors Association (NECA).
3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70E, Electrical Safety Requirements for Employee Workplaces.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Electrical service components.
   b. Nameplates, signs, and labels.

B. Quality Control Submittals:

1. Voltage field test results.
2. Voltage balance report.
3. Equipment line current report.
4. Factory test certification and reports for all major electrical equipment.
5. Site test certification and reports as specified in other Division 26, Electrical sections.

1.04 QUALITY ASSURANCE

A. Provide comprehensive short circuit, protective device coordination and arc flash studies per Section 26 05 70, Electrical Systems Analysis. Initial complete short circuit, protective device coordination and arc flash studies shall be submitted, reviewed, and approved before major electrical equipment Shop Drawings will be reviewed.

B. Provide lightning protection design and construction for abovegrade structures per Section 26 41 00, Facility Lightning Protection.

1.05 SCOPE OF WORK

A. Provide, install, and test low voltage switchgear and two low voltage motor control centers.

B. Provide, install, and test modifications to existing low voltage switchboard and low voltage motor control centers as shown.

C. Provide, install, and test diesel engine generator set.

D. Furnish, install, and test low voltage site power distribution system as specified and/or shown.

E. Furnish and install the low voltage and control duct bank systems as shown.

F. Furnish, install, terminate, and test all interconnecting power, control, and instrumentation wiring as shown on the One-Line Diagrams, riser diagrams and P&ID Drawings.

G. Furnish and install all conduit, wiring, and field connections for all motors, motor controllers, control devices, control panels, and electrical equipment furnished under other divisions of these Specifications.

H. Furnish and install equipment grounding conductors sized per Table 250-122 of the NEC unless otherwise shown on the Drawings, in all conduits throughout the entire plant.

I. Furnish and install raceways for the fiber optic cable system as required to implement fiber optic data links shown on the P&ID Drawings. Install an inner duct/outer duct system as shown and specified. Install fiber optic cable furnished by PICS subcontractor. Termination and testing by PICS subcontractor. Provide accurate estimate of fiber optic cable lengths to the PICS subcontractor.

J. Furnish and install a complete raceway system for data highway cables and specialty cables systems. Install manufacturer-supplied data highway cables and other specialty cable systems in accordance with the system manufactures' installation instructions. Review the raceway layout, prior to installation, with the PICS subcontractor and cable manufacture to ensure raceway compatibility with the systems and materials being furnished. Where redundant cables are furnished, install cables in separate raceways.

K. Provide support to the PICS subcontractor for installation, wiring, and termination of all control panels, field instruments, lightning, and surge protection equipment at process instrumentation transmitters, and computer equipment. Install vendor furnished cables specified under other Divisions of the Specification.

L. Furnish and install conduit, wiring, and terminations for adjustable frequency drives, harmonic filters, and transformers furnished under other Divisions of these Specifications.

M. Furnish and install power wiring for all heating, ventilation, and air conditioning (HVAC) equipment furnished under other divisions of these specifications, including power wiring for 120-volt unit heaters, thermostats, fan motors, dampers and other HVAC inline unit wiring shown on the Drawings.

N. Furnish, install, and wire all site and facility lighting as shown on the Drawings.

O. Conduct and participate in all electrical and PICS subcontractor's testing. Specifically all operational readiness tests and functional acceptance tests shall be jointly conducted by the PICS subcontractor and the Electrical subcontractor.

P. Furnish and install all telephone/data outlet raceway systems as shown and required for satisfactory operation.

Q. Sequence work to meet the Contractor's overall schedule and construction sequence.

R. Prepare and furnish electrical and instrumentation conduit layout Shop Drawings for yard electrical, within and under all roads, buildings and structures to the Engineer for approval prior to commencing work. Layouts shall include but not be limited to equipment, pull boxes, manholes, handholes, conduit routing, dimensioning, methods and location of supports, reinforcing, encasement, materials, conduit sizing, equipment access, potential conflicts, building and yard lighting, and all other pertinent technical specifications for all electrical and instrumentation conduits and equipment to be furnished.

S. The work shall include complete testing of all equipment and wiring at the completion of work and making any necessary corrections or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

T. Contractor shall provide their own temporary power for miscellaneous power (drills, pumps, etc.). Any temporary added shall be removed at job completion.

U. Complete coordination with other Contractors. Contractor shall coordinate with all other Contractor's equipment submittals and obtain all relevant submittals.

V. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the site, in which work under this Division is to be performed. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the Site, and noted the locations and conditions under which the work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work.

1.06 ELECTRIC AND TELEPHONE SERVICE DIVISION OF RESPONSIBILITY

A. Incoming aerial electrical service facilities provided by the serving utility as part of its normal obligation to customers is work provided outside this Contract. Under this Contract provide customer required service provisions and electrical work including, but not limited to, primary trench and backfill, primary duct system, transformer pad site preparation, transformer pad, metering components and associated conduit, and secondary facilities. Schedule and coordinate work of serving utility as required to provide electric service to the Work.

B. Incoming telephone service facilities provided by the serving utilities as part of their normal obligation to customers. Under this Contract provide customer required service provisions and electrical work.

1.07 AUTHORITY HAVING JURISDICTION APPROVAL

A. As a minimum, provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the Authority having Jurisdiction (AHJ) or the specifications, material and equipment shall be labeled or listed by a Nationally Recognized Testing Laboratory (NRTL) or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied listing mark or label by a NRTL.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.08 ENVIRONMENTAL CONDITIONS

A. The areas of the plant are classified hazardous Class I, Division 1, Group D, due to the potential for occurrence of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Refer to Drawings for plant hazardous area classifications. Use materials and methods required for such areas.

PART 2 PRODUCTS

2.01 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.

D. Provide equipment panels installed outdoors in direct sun with sun shields.

E. Provide materials and equipment listed/labeled by a NRTL to UL standards where they have been established by the agency.

2.02 EQUIPMENT FINISH

A. Interior: Manufacturer’s standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with ANSI No. 61, light gray color.

B. Exterior: White color.

2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: Red, engraved to a white core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 1/8 inch.
2. Other Electrical Equipment: 1/4 inch.

2.04 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

B. Warning labels for arc flash hazards shall be provided per NEC code.

C. Based on the results of arc-flash calculations performed as specified in Section 26 05 70, Electrical Systems Analysis, provide appropriate warning labels on all electrical equipment.

PART 3 EXECUTION

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer. Coordinate the conduit installation with other trades and the actual supplied equipment. Obtain information relevant to the placement of electrical work and in case of any interference with other work, processed as directed by the Engineer and furnished all labor and materials necessary to complete the Work in an approved manner.

B. Check approximate locations of light luminaires, switches, receptacles, disconnect switches, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing. Any adjustments required in the field shall be provided at no additional cost to the Owner.

C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Keep openings in boxes and equipment closed during construction.

E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

F. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.

G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of the approved equipment at no additional cost to the Owner.

H. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement or equipment and/or layout other than specified herein, shall be done by the Contractor at his/her own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his/her own or others, caused by such redesign.

I. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported with 1/2-inch spacers to provide a clearance between wall and equipment.

J. All floor mounted electrical equipment shall be placed on 4-inch thick (3/4-inch, 45-degree chamfer at all exposed edges) concrete pads, provide reinforcement, anchors, etc.

K. The Contractor shall coordinate with the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the Contractor without additional expense to the Owner. In case interference develops, the Engineer is to decide which equipment, piping, etc., must be relocated, regardless of which was installed first.

L. Raceways and conductors for lighting, switches, receptacles, and other miscellaneous low voltage power and signal system as specified are not shown on the Drawings. Raceways and conductors shall be provided as required for a complete and operating system. Homeruns, as shown on the Drawings, are to assist the Contractor in identifying raceways to be run

exposed and raceways to be run concealed. Raceways shall be installed concealed in all finished spaces and may be installed exposed or concealed in all process spaces. Raceways installed exposed shall be near the ceiling or along walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes hoists, monorails, equipment hatches, doors, windows, etc. Raceways installed concealed shall be run in the center of concrete floor slabs, above suspended ceilings, or in partitions as required.

M. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

N. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

3.02 ANCHORING, BRACING, AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Section 01 61 00, Common Product Requirements.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:

1. Analog control circuits from devices in same general area to same destination.
    a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
    c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
    d. Raceways shall be sized per General Circuit and Raceway Schedule and shall not exceed 40 percent fill.
    e. Changes shall be documented on Record Drawings.

2. Discrete control circuits from devices in the same general area to the same destination.
    a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
    c. Raceways shall be sized per the General Circuit and Raceway Schedule and shall not exceed 40 percent fill.
    d. Changes shall be documented on Record Drawings.
3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
    a. Lighting Circuits: Combine no more than three circuits, with separate neutrals, to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits, with separate neutrals, to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs: Field mark switchgear, motor control centers, panelboards, etc. to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment. Refer to Section 26 05 70, Electrical Systems Analysis for additional requirements.

B. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying a building, and the area served by each.

C. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
2. Switchgear, motor control center, dry-type transformer, and terminal junction box nameplates shall include equipment designation.

3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

D. Procedural Signs: Provide procedural signs for Kirk-Key interlocks and main-tie-main operation sequences.

3.05 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain Shop Drawings and templates from equipment vendors or other subcontractors and locate the concealed conduits before the floor slab is poured.

C. Where setting Drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installation of such conduits to be exposed. Request for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

D. Seal all openings, sleeves, penetrations and slots as specified in Section 26 05 33, Raceway and Boxes.

3.07 CUTTING AND PATCHING

A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete as specified in Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.

B. Install work at such time as to require the minimum amount of cutting and patching.

C. Do not cut joists, beams, girders, columns, or any other structural members.

D. Cut openings only large enough to allow easy installation of the conduit.

E. Patching to be of the same kind and quality of material as was removed.

F. The completed patching work shall restore the surface to its original appearance or better.

G. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

H. Remove rubble and excess patching materials from the premises.

3.08 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.09 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor’s convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

3.10 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
   a. Submit Voltage Field Test Report within 5 days of test.
4. Unbalance Corrections:
   a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
   b. Obtain a written certification from a responsible power company official that the voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
   b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
   c. C12.1, Code for Electricity Metering.
   d. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
   e. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   f. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   g. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories, Inc. (UL):
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 943, Standard for Ground-Fault Circuit-Interrupters.

g. 1059, Standard for Terminal Blocks.
h. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Intrinsic safety barriers.
   j. Firestopping.
   k. Enclosures: Include enclosure data for products having enclosures.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 Volt to 600 Volts: Six of each type and each current rating installed.

1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied NRTL listing mark.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 amps to 800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. NEMA AB 1 and UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

D. Short Circuit Interrupting Ratings:

1. Not less than the following RMS symmetrical currents for the indicated ratings:
   a. Less than 250V ac: 10,000 amps unless otherwise shown on the Drawings.
   b. 250-600V ac: 65,000 amps unless otherwise shown on the Drawings.
2. Series Connected Ratings: Do not apply series connected short circuit ratings.

E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

G. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

H. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

I. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Enclosures: See Article Enclosures.

E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:

1. Class: RK-1.
2. Type: Dual element, with time delay.
3. Manufacturers and Products:
   a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
   b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O-rings and silver links.
3. Manufacturers and Products:
   a. Bussmann; Type KRP-C.
   b. Littelfuse, Inc.; Type KLPC.

D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
   a. Bussmann.
   b. Littlefuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Size: 30mm.

C. Selector Switch Operating Lever: Standard.

D. Indicating Light: Push-to-test, LED.

E. Pushbutton Color:

1. ON or START: Red.
2. OFF or STOP: Black.

F. Pushbutton and selector switch lockable in OFF position where indicated.

G. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.

3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64 inch.

H. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
   a. General Electric Co.; Type CR 104P.
   b. Square D Co.; Type T.
   c. Eaton/Cutler-Hammer; Type 10250T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   a. Square D Co.; Type SK.
   b. General Electric Co.; Type CR 104P.
   c. Eaton/Cutler-Hammer; Type E34.
   d. Crouse-Hinds; Type NCS.

2.06 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.

J. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.
3. Electrovert USA Corp.

2.07 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. NEMA ICS 2, Designation: A600 (600 volts).

C. Time Delay Relay Attachment:

1. Pneumatic type, timer adjustable from 0.2 second to 60 seconds (minimum).
2. Field convertible from ON delay to OFF delay and vice versa.

D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Type M 600
2. General Electric Co.; Type CR120B.
3. Square D; Type X.

2.08 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:

1. Square D Co.; Type F.
2. Eaton/Cutler-Hammer.
3. General Electric Co.

2.09 RESET TIMER

A. Drive: Synchronous motor, solenoid-operated clutch.

B. Mounting: Semiflush panel.

C. Contacts: 10 amps, 120 volts.

D. Manufacturers and Products:

1. Eagle Signal Controls; Bulletin 125.
2. Automatic Timing and Controls; Bulletin 305.

2.10 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0 hour to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush panel.

D. Manufacturers and Products:

1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
2. Eagle Signal Controls; Bulletin 705.

2.11 PHASE MONITOR RELAY

A. Features:

1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
2. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
3. Adjustable trip and time delay settings.
4. Transient Protection: 1,000V ac.
5. Mounting: Multipin plug-in socket base.

B. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

2.12 MAGNETIC CONTACTOR

A. UL listed.

B. Electrically operated, electrically held.

C. Main Contacts:

1. Power driven in one direction with mechanical spring dropout.
2. Silver alloy with wiping action and arc quenchers.
3. Continuous-duty, rated: As shown.
4. Poles: As shown.

D. Control: As shown.

E. Auxiliary Contacts: Quantity as shown, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Enclosures: See Article Enclosures.

G. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Class A201.
2. General Electric Co.; CR 353.
3. Square D Co.; Class 8910.

2.13 MAGNETIC LIGHTING CONTACTOR

A. Comply with NEMA ICS 2; provide UL 508 listing.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and mechanically held in both OPEN and CLOSED position.

D. Main Contacts:

1. Double-break, continuous-duty, rated 20 amperes, unless otherwise shown, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts; 65,000 amps rms symmetrical at 480 volts.
2. Marked for electric discharge lamps, tungsten, and general purpose loads.
3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.
4. Capable of operating in any position.
5. Visual indication for each contact.

E. Auxiliary contact relay for two-wire control.

F. Provision for remote pilot lamp with use of auxiliary contacts.

G. Clamp type, self-rising terminal plates for solderless connections.

H. Enclosures: See Article Enclosures.

I. Manufacturers and Products:

1. ASCO.
2. Eaton/Cutler-Hammer; Class A202.
3. General Electric Co.; Class CR360 (mechanically held).
4. Square D; Class 8903, Type LL (mechanically held).

2.14 UNINTERRUPTIBLE POWER SUPPLY (UPS) AND ASSOCIATED EQUIPMENT

A. Provide 10kVa/9kW UPS in NEMA 1 enclosure as shown on the Drawings. The UPS shall have the following characteristics:

1. 10 kVA/9 kW UPS:
   a. Input Voltage: 120/208 V, 3-phase, 4-wire, and 60-Hz.
   b. Output Voltage: 120/208V, 3-phase, 4-wire, and 60-Hz.
2. Topology: Online, Double Conversion.
3. The UPS shall include self-diagnostic monitoring package. LED indicators for ac line, battery power, ready charging and alarm conditions. Features coded audible alarm for low battery, high battery, near low battery, check battery, check inverter, overload, etc. Digital multimeter display.
4. Provide maintenance free batteries sized for 8 minutes backup at full load, and 20 minutes backup at half load.
5. Battery charger to charge batteries when normal input power is available.
6. The UPS shall be capable of providing a dry contact output rated 5A, 120V corresponding to a FAIL condition of the UPS. The signal shall be relayed to the plant PLC.
7. For 120/208V ac three-phase UPSs, provide a three breaker (BIB, MBP, MIS) Maintenance Bypass Switch to testing and removal of the UPS without disruption of power to the load as follows:
   a. Normally the MBP breaker is open and both the BIB and MIS breakers are closed feeding line power to the UPS and feeding UPS power to the load respectively.
   b. Provide a Kirk Key interlock on the MIS and MBP breakers to prevent both from being closed at the same time.

c. Provide pushbutton on the Maintenance Bypass Switch to transfer the UPS internal static transfer switch to the BYPASS mode along with OK TO BYPASS indicator indicating that the UPS is in internal BYPASS mode.
d. Once the UPS is in internal BYPASS mode and the Kirk Key is inserted, closing the MBP breaker will parallel the UPS with the incoming line power.
e. Once the MBP breaker is closed, the Kirk Key can be removed and inserted in the MIS breaker and that breaker can be opened placing the load on line power.
f. Opening the BIB breaker will allow the UPS to be removed and replaced if necessary.

8. Provide circuit, 120/208V panelboard with integral SPD to feed all of the loads for each 1-phase UPS loads, as shown.
9. Include 2-year warranty, including parts and labor, and onsite startup and certification by manufacturers.
10. The UPS shall be as manufactured by Eaton; 9355.

2.15 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/ A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.

C. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:

1. Material: Extruded from Type 6063-T6 aluminum alloy.
2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:

1. Material: Fire retardant, fiber reinforced vinyl ester resin.
2. Channel fitting of same material as channel.
3. Nuts and bolts of long glass fiber reinforced polyurethane.

G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

2.16 INTRINSIC SAFETY BARRIER

A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.

B. Rating: Power source shall be rated 24 volts dc, nominal, with not more than 250 volts available under fault conditions.

C. Contact Rating: 5 amps, 250 volts ac.

D. Mounting: Rail or surface.

E. Manufacturers and Products:

1. MTL, Inc.; Series 2000 or Series 3000.
2. R. Stahl, Inc.

2.17 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum.

B. Manufacturer: U.S. Mat and Rubber Company.

2.18 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

2.19 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections:

1. Except as shown otherwise, provide electrical enclosures according to the following table:

Enclosures			
Location	**Finish**	**Environment**	**NEMA 250 Type**
Indoor	Finished	Dry	1
Indoor	Unfinished	Dry	1
Indoor	Unfinished	Industrial Use	12
Indoor and Outdoor	Any	Wet	4
Indoor and Outdoor	Any	Denoted "WP"	3R
Indoor and Outdoor	Any	Wet and Corrosive	4X 304 Stainless Steel
Indoor and Outdoor	Any	Wet, Dust or Oil	13
Indoor and Outdoor	Any	Hazardous Gas	7
Indoor and Outdoor	Any	Hazardous Dust	9

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.

B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. Aluminum Raceway: Extruded aluminum or carbon steel with neoprene material isolators.
   b. PVC-Coated Conduit: PVC coated.
   c. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
2. Interior, Corrosive (Wet or Dry) Locations:
   a. Aluminum Raceway: Extruded aluminum.
   b. PVC Conduit: Type 316 stainless steel or nonmetallic.
   c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.
3. Outdoor, Noncorrosive Locations:
   a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
   b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel or carbon steel with neoprene material isolators.
4. Outdoor Corrosive Locations:
   a. PVC Conduit: Type 316 stainless steel or nonmetallic.
   b. Aluminum Raceway: Aluminum or carbon steel with neoprene material isolators.
   c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.
5. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.04 INTRINSIC SAFETY BARRIERS

A. Install in compliance with ISA RP12.06.01.

B. Arrange conductors such that wiring from hazardous areas cannot short to wiring from nonhazardous area.

C. Stencil “INTRINSICALLY SAFE CIRCUIT” on all boxes enclosing barriers.

3.05 SWITCHBOARD MATTING

A. Install 36-inch width at switchgear, switchboard, motor control centers, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

3.06 FIRESTOPS

A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. B3, Standard Specification for Soft or Annealed Copper Wire.
   c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
   b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
4. Insulated Cable Engineer's Association, Inc. (ICEA):
   a. S-58-679, Standard for Control Cable Conductor Identification.
   b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
5. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
   c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.

e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
8. Underwriters Laboratories Inc. (UL):
   a. 13, Standard for Safety for Power-Limited Circuit Cables.
   b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
   c. 62, Standard for Safety for Flexible Cord and Cables.
   d. 486A-486B, Standard for Safety for Wire Connectors.
   e. 486C, Standard for Safety for Splicing Wire Connectors.
   f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety for Service-Entrance Cables.
   h. 1072, Standard for Safety for Medium-Voltage Power Cables.
   i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   j. 1569, Standard for Safety for Metal-Clad Cables.
   k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

1. Wire and cable descriptive product information.
2. Wire and cable accessories descriptive product information.
3. Cable Pulling Calculations:
   a. Calculations shall be submitted and reviewed before cable installation.
   b. Provide cable pulling calculations for the following cable installations:
      1) Multi-conductor 600-volt cable sizes larger than #2 AWG that cannot be hand pulled.
      2) Power and control conductor, and control and instrumentation cable installations in ductbanks.
      3) Feeder circuits, single conductors #4/0 and larger.

B. Informational Submittals: Certified Factory Test Report for conductors 600 volts and below.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

C. Insulation: THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

D. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

C. Type 2, Multiconductor Power Cable:

1. General:
   a. Meet or exceed UL 1581 for cable tray use.
   b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
   c. Overall Jacket: PVC.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
   c. UL rated VW-1 or listed Type XHHW-2.
   d. Color Code:
      1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.
3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2 3 4	0.42 0.45 0.49	45
10	10	2 3 4	0.54 0.58 0.63	60
8	10	3 4	0.66 0.75	60
6	8	3 4	0.74 0.88	60
4	6	3 4	0.88 1.04	60 80
2	6	3 4	1.01 1.16	80
1	6	3 4	1.10 1.25	80

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
1/0	6	3 4	1.22 1.35	80
2/0	4	3 4	1.32 1.53	80
3/0	4	3 4	1.40 1.60	80
4/0	4	3 4	1.56 1.78	80 110

5. Manufacturers:
   a. Okonite Co.
   b. Southwire.

D. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

E. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.

2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand, tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nylon.
   e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

F. Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wires.
   c. Pair drain wire size AWG 20, group drain wire size AWG 18.
   d. Insulation: 15-mil PVC.
   e. Jacket: 4-mil nylon.
   f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
   g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
36	1.33	80
50	1.56	80

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

G. Type 6, 18 AWG, Multitwisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wire size AWG 18.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nylon.
   e. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.48	45
8	0.63	60
12	0.75	60
16	0.83	60
24	1.10	80
36	1.21	80
50	1.50	80

3. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

H. Type 7, Multiconductor Metal-Clad (UL Type MC) Power Cable:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	12 or 3x16	3 4	0.79 0.85	50
10 AWG	10 or 3x14	3 4	0.82 0.90	50
8 AWG	10 or 3x14	3 4	0.85 1.00	50
6 AWG	8 or 3x12	3 4	0.99 1.10	50
4 AWG	8 or 3x12	3 4	1.08 1.20	50
2 AWG	6 or 3x10	3 4	1.24 1.45	50
1 AWG	6 or 3x10	3 4	1.40 1.55	50
1/0 KCM	6 or 3x10	3 4	1.52 1.60	50
2/0 AWG	4 or 3x8	3 4	1.67 1.75	50

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
4/0 AWG	4 or 3x8	3 4	1.93 2.10	60
250 KCM	4 or 3x8	3 4	2.11 2.20	60
350 KCM	3 or 3x8	3 4	2.39 2.50	60
500 KCM	2 or 3x8	3 4	2.80 2.90	75

7. Manufacturers and Products:
   a. Okonite Co.; Type CLX.
   b. Southwire Type MC.
   c. General Cable, CCW Armored Power.

I. Type 8, Multiconductor Adjustable Frequency Drive Power Cable:

1. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
   c. Grounding Conductors: Insulated stranded copper.
2. Sheath:
   a. UL 1277 Type TC, 90 degrees C.
   b. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
12 AWG	12	4	0.655	50
10 AWG	10	4	0.769	50
8 AWG	8	4	0.940	50
6 AWG	6	4	1.038	50

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
4 AWG	4	4	1.180	50
2 AWG	2	4	1.351	50

5. Manufacturers and Products:
   a. Alpha Wire; Series V.
   b. Belden; Series 29500.
   c. LAPP USA; OLFLEX VFD Slim.

J. Type 9, Multiconductor Metal-Clad (UL Type MC) Power Cable for Adjustable Frequency Drive Applications:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper. Provide three symmetrical grounding conductors.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	3x16	3 4	0.79 0.85	50
10 AWG	3x14	3 4	0.82 0.90	50
8 AWG	3x14	3 4	0.85 1.00	50

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
6 AWG	3x12	3 4	0.99 1.10	50
4 AWG	3x12	3 4	1.08 1.20	50
2 AWG	3x10	3 4	1.24 1.45	50
1 AWG	3x10	3 4	1.40 1.55	50
1/0 KCM	3x10	3 4	1.52 1.60	50
2/0 AWG	3x8	3 4	1.67 1.75	50
4/0 AWG	3x8	3 4	1.93 2.10	60
250 KCM	3x8	3 4	2.11 2.20	60
350 KCM	3x8	3 4	2.39 2.50	60
500 KCM	3x8	3 4	2.80 2.90	75

7. Manufacturer and Product: Okonite Co.; Type CLX MC-HL.

2.03 SPECIAL CABLES

A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.

4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
6. Manufacturer and Product: Belden; 7852A.

B. Type 32, DeviceNet Round Cable, 600V, Class 1, Two Twisted, Shielded Pairs with Common Overall Shield:

1. Outer Jacket: PVC.
2. Overall Shield: Tinned copper braid, 18 AWG tinned copper drain wire.
3. Individual Pair Shield: Aluminum foil-polyester tape.
4. Dimension: 0.460-inch nominal OD.
5. Conductors:
   a. 15 AWG stranded tinned copper.
   b. Insulation: FEP.
6. Manufacturer and Product: Belden; 7897A.

C. Type 33, DeviceNet Flat Cable, 600V, Class 1, Four Conductor Unshielded Network Trunk Cable:

1. Outer Jacket: Thermoplastic Elastomer (TPE).
2. Conductors: Four conductor, unshielded, flat configuration.
3. Manufacturer and Product: Allen-Bradley; 1485C-P1E.

D. Type 34, Profibus PA Cable, 300V:

1. Outer Jacket: PVC.
2. Shield: Aluminum foil-polyester tape, 20 AWG tinned copper drain wire.
3. Dimension: 0.253-inch nominal OD.
4. Conductors:
   a. 18 AWG stranded tinned copper.
   b. Insulation: polyolefin.
5. Manufacturer and Product: Belden; 3076F.

2.04 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
   a. 30-mil, elastomer.
   b. Manufacturers and Products:
      1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
   b. Manufacturers and Products:
      1) Raychem; Type D-SCE or ZH-SCE.
      2) Brady, Type 3PS.
2. Heat Bond Marker:
   a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
   b. Self-laminating protective shield over text.
   c. Machine printed black text.
   d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
   a. Chemical-resistant white tag.
   b. Size: 1/2 inch by 2 inches.
   c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.

3) ILSCO.

2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulink.
      3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
   a. UL 486C.
   b. Plated steel, square wire springs.
   c. Manufacturers and Products:
      1) Thomas & Betts.
      2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
   a. Two piece compression type with set screw in brass barrel.
   b. Insulated by insulator cap screwed over brass barrel.
   c. Manufacturers:
      1) 3M Co.
      2) Thomas & Betts.
      3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy; Hydent.
      3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Manufacturers and Products:
      1) Thomas & Betts; Locktite.
      2) Burndy; Quiklug.
      3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
   a. Thomas & Betts; SHRINK-KON.
   b. Raychem; RNF-100 and ES-2000.

G. Data Cable Accessories: Terminators, connectors, and junctions necessary for a complete Profibus DP or Profinet system.

1. Profibus DP connector:
   a. Manufacturers and Products:
   b. Brad Harrison; MA9D00-42 and MA9D01-42.
2. Profinet connector: RJ-45.

2.06 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

2.07 MANUFACTURED WIRING SYSTEMS

A. System Rating:

1. 20 amperes load-carrying capacity each phase with final assemblies consisting of maximum of three-phase conductors.
2. Composition: Type MC cable with 90 degrees C insulation and stranded copper conductors.

B. Cable Configuration: Three, single-phase, five-wire circuit with standard color wire coding:

1. 208/120 Volt: Black, red, blue, white, green.
2. 480/277 Volt: Brown, orange, yellow, white, green.

C. Locking Mechanism: Latch/strike with voltage clearly marked on latch.

D. NFPA 262 listed for use in air handling plenums, listed to connect or disconnect under load, and manufactured in accordance with NFPA 70, Article No. 604.

2.08 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.09 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

B. Conductors above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 6 partial discharge level test for EPR insulated cable.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer’s recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer’s recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors and aluminum conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

B. Conductors Above 600 Volts:

1. Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. Colors:
   a. Grounded Neutral: White.
   b. Phase A: Brown.
   c. Phase B: Orange.
   d. Phase C: Yellow.

3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:
    a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
    b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate uninsulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40 90 00, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. Cable Protection:
    a. Under Infinite Access Floors: May install without bundling.
    b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
    c. Maintain integrity of shielding of instrumentation cables.
    d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.05 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 600-volt single conductors and cables, except those rated Type TC throughout their entire exposed length, at splices in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Wrap conductors of same circuit entering from separate conduit together as a single cable.

C. Follow tape manufacturer's installation instructions.

D. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.06 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as specified in Section 31 23 23.15, Trench Backfill.

B. Warning Tape: Install approximately 6 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data for the following:
      1) Exothermic weld connectors.
      2) Mechanical connectors.
      3) Compression connectors.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL:
   a. Confirm conformance with UL standards.
   b. Supply with an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper-clad.

B. Diameter: Minimum 3/4 inch.

C. Length: 20 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.
3. Manufacturers:
   a. Erico Products, Inc. Cadweld and Cadweld Exolon.
   b. Thermoweld.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
   a. Burndy Corp.; Hyground Irreversible Compression.
   b. Thomas and Betts Co.
   c. ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.

2.04 GROUNDING WELLS

A. Ground rod box complete with cast-iron riser ring and traffic cover marked “GROUND ROD”.

B. Manufacturers and Products:

1. Christy Co.; No. G5.
2. Lightning and Grounding Systems, Inc.; I-R Series.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding: In compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

C. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.

D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

G. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box. If none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Use furnished ground lug in motor connection box. If none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

3.05 GROUNDING WELLS

A. Install for ground rods located inside buildings, asphalt and paved areas, and where shown on Drawings.

B. Install riser ring and cover flush with surface.

C. Place 9 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Belowgrade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.07 METAL STRUCTURE GROUNDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

C. Bond neutrals of pad-mounted transformers to locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.10 LIGHTNING PROTECTION SYSTEMS

A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.11 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

3.12 FIELD QUALITY CONTROL

A. As specified in Section 26 08 00, Commissioning of Electrical Systems.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
   b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
   a. National Electrical Contractor's Association, Inc. (NECA): Installation standards:
   b. 101, Standard for Installing Steel Conduit (Rigid, IMC, EMT).
   c. 105, Recommended Practice for Installing Metal Cable Trays.
   d. 111, Standard for Installing Nonmetallic Raceway (RNC, ENT, LFNC).
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. C80.1, Electrical Rigid Steel Conduit (ERSC).
   c. C80.3, Steel Electrical Metallic Tubing (EMT).
   d. C80.6, Electrical Intermediate Metal Conduit (EIMC).
   e. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   f. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
   g. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   h. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.

i. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
j. VE 1, Metallic Cable Tray Systems.

5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. Underwriters Laboratories Inc. (UL):
   a. 1, Standard for Safety for Flexible Metal Conduit.
   b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
   c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
   d. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
   e. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
   f. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
   g. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
   h. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
   i. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
   j. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
   k. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
   l. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   m. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s Literature:
   a. Rigid galvanized steel conduit.
   b. Electric metallic tubing.
   c. PVC Schedule 40 conduit.
   d. PVC Schedule 80 conduit.
   e. PVC-coated rigid galvanized steel.
   f. Flexible metal, liquid-tight conduit.
   g. Flexible metal, nonliquid-tight conduit.
   h. Conduit fittings.
   i. Device boxes for use in hazardous areas.
   j. Junction and pull boxes used at or below grade.
   k. Large junction and pull boxes.
   l. Terminal junction boxes.

2. Precast Manholes and Handholes:
   a. Dimensional drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Accessory information.
3. Equipment and machinery proposed for bending metal conduit.
4. Method for bending PVC conduit less than 30 degrees.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

C. PVC-coated conduit bodies and cast metal boxes shall be provided by the PVC-coated rigid steel conduit manufacturer.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. Intermediate Metal Conduit (IMC):

1. Meet requirements of NEMA C80.6 and UL 1242.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

C. Electric Metallic Tubing (EMT):

1. Meet requirements of NEMA C80.3 and UL 797.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

D. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.
3. Furnish without factory-formed bell.
4. Refer to Section 40 95 80, Fiber Optic Communications System for innerduct specifications.

E. PVC Schedule 80 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

F. PVC Tubing (Type EB):

1. Meet requirements of NEMA TC 6 and UL 651A.
2. UL listed for reinforced concrete encasement and 90 degrees C insulated conductors.

G. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1.
2. Material:
   a. Meet requirements of NEMA C80.1 and UL 6.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

H. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

I. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 1.
2. Material: Galvanized steel.

J. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Material: PVC core with fused flexible PVC jacket.
2. UL 1660 listed for:
   a. Dry Conditions: 80 degrees C insulated conductors.
   b. Wet Conditions: 60 degrees C insulated conductors.
3. Manufacturers and Products:
   a. Carlon; Carflex or X-Flex.
   b. T & B; Xtraflex LTC or EFC.

K. Innerduct:

1. Resistant to spread of fire, per requirements of UL 2024.
2. Smooth or corrugated HDPE.

2.02 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
   a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
   b. Manufacturers and Products:
      1) Appleton; Series BU-I.
      2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
   a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
   b. Manufacturers and Products:
      1) Appleton; Series GIB.
      2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
   a. Material: Malleable iron with insulated throat with bonding screw.
   b. UL listed for use in wet locations.
   c. Manufacturers and Products:
      1) Appleton, Series HUB-B.
      2) O-Z/Gedney; Series CH.
      3) Meyers; ST Series.

5. Conduit Bodies:
    a. Sized as required by NFPA 70.
    b. Manufacturers and Products (For Normal Conditions):
        1) Appleton; Form 35 threaded unilets.
        2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
        3) Killark; Series O electrolets.
        4) Thomas & Betts; Form 7 or Form 8.
    c. Manufacturers (For Hazardous Locations):
        1) Appleton.
        2) Crouse-Hinds.
        3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
    a. Concrete tight, hot-dip galvanized malleable iron.
    b. Manufacturers and Products:
        1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
        2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type EYF, EYM, or ESU.
        2) Crouse-Hinds; Type EYS or EZS.
        3) Killark; Type EY or Type EYS.
9. Drain Seal:
    a. Manufacturers and Products:
        1) Appleton; Type EYD.
        2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type ECDB.
        2) Crouse-Hinds; ECD.
11. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement:
            a) Appleton; Type DF.
            b) Crouse-Hinds; Type XD.
        2) Expansion Movement Only:
            a) Appleton; Type XJ.
            b) Crouse-Hinds; Type XJ.
            c) Thomas & Betts; XJG-TP.
12. Cable Sealing Fitting:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.

c. Manufacturers and Products:
   1) Appleton; CG-S.
   2) Crouse-Hinds; CGBS.

B. Electric Metallic Tubing:

1. Meet requirements of UL 514B.
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
3. Electro zinc-plated inside and out.
4. Raintight.
5. Coupling Manufacturers and Products:
   a. Appleton; Type 95T.
   b. Crouse-Hinds.
   c. Thomas & Betts.
6. Connector Manufacturers and Products:
   a. Appleton; Type ETP.
   b. Crouse-Hinds.
   c. Thomas & Betts.

C. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

D. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
   a. Thomas & Betts; Series 5331.
   b. O-Z/Gedney; Series 4Q.

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel.
3. Throat: Nylon insulated.
4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product: Appleton; Series 7400.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
   a. Carlon; Type LT.
   b. O-Z/Gedney; Type 4Q-P.
   c. Thomas & Betts; Series 6300.

G. Flexible Coupling, Hazardous Locations:

1. Approved for use in atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
3. Outer bronze braid and an insulating liner.
4. Conductivity equal to a similar length of rigid metal conduit.
5. Manufacturers and Products:
   a. Crouse-Hinds; Type ECGJH or Type ECLK.
   b. Appleton; EXGJH or EXLK.

H. Watertight Entrance Seal Device:

1. New Construction:
   a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
   b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
2. Cored-Hole Application:
   a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
   b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Metal:

1. Box: Malleable iron
2. Cover: Gasketed, weatherproof, malleable iron, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.

5. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS or Type FD.
   b. Appleton; Type FS or Type FD.
   c. Killark.
6. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA or Type EAJ.
   b. Appleton; Type GR.

C. Cast Aluminum:

1. Material:
   a. Box: Cast, copper-free aluminum.
   b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3.
4. Lugs: Cast mounting.
5. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS-SA or Type FD-SA.
   b. Appleton; Type FS or Type FD.
   c. Killark.
6. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA-SA.
   b. Appleton; Type GR.

D. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
   a. Exterior Surfaces: 40-mil PVC.
   b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
   a. Robroy Industries.
   b. Ocal.

E. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers.

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code-gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron, electrogalvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Hinged with screws.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Nonhinged Type:
   a. Crouse-Hinds; Series W.
   b. O-Z/Gedney; Series Y.
7. Manufacturer and Product, Surface Mounted, Hinged Type: -Z/Gedney; Series YW.
8. Manufacturers and Products, Recessed Type:
   a. Crouse-Hinds; Type WJBF.
   b. O-Z/Gedney; Series YR.

E. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished or copper-free aluminum with drilled and tapped conduit entrances.
3. Cover: Nonhinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
   a. Crouse-Hinds; Type EJB.
   b. Appleton; Type AJBEW.

F. Large Cast Aluminum Box:

1. NEMA 250 Type 4.
2. Box: Cast copper-free aluminum, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Type:
    a. Crouse-Hinds; Series W-SA.
    b. O-Z/Gedney; Series YS-A, YL-A.
    c. Killark.

G. Large Stainless Steel Box:

1. NEMA 250 Type 4X.
2. Box: 14-gauge, ASTM A240/A240M, Type 316 stainless steel, with white enamel painted interior mounting panel.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

H. Large Steel Box:

1. NEMA 250 Type 12.
2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide finish as approved by JEA.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

I. Large Nonmetallic Box:

1. NEMA 250 Type 4X.
2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
3. Cover: Nonhinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Conduit hubs and mounting lugs.

6. Manufacturers and Products:
   a. Crouse-Hinds; Type NJB.
   b. Carlon; Series N, C, or H.
   c. Robroy Industries.

J. Concrete Box, Nontraffic Areas:

1. Box: Reinforced, cast concrete with extension.
2. Cover: Steel diamond plate with locking bolts.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Size: 10 inches by 17 inches, minimum.
5. Manufacturers and Products:
   a. Utility Vault Co.; Series 36-1017.
   b. Christy, Concrete Products, Inc.; N9.
   c. Quazite; “PG” Style.

K. Concrete Box, Traffic Areas:

1. Box: Reinforced, cast concrete with extension and bottom slab.
2. Cover: Steel checked plate; H/20 loading with screw down.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Manufacturers and Products:
   a. Christy, Concrete Products, Inc.; B1017BOX.
   b. Utility Vault Co.; 3030 SB.

2.05 TELEPHONE AND DATA OUTLET

A. Provide outlet boxes and cover plates meeting requirements of TIA 569B.

2.06 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:

1. Separate connection point for each conductor entering or leaving box.
2. Spare Terminal Points: 50 percent, minimum.

2.07 SURFACE METAL RACEWAY

A. General:

1. Meet requirements of UL 5.
2. Material: Two-piece, code-gauge steel.

3. Finish: Factory applied rust inhibiting primer and gray semi-gloss finish suitable for field painting.
4. Configuration: Single, 1-17/32-inch by 2-3/4-inch section, unless otherwise indicated.

B. Fittings and Accessories:

1. Wire clips at 30 inches on center.
2. Couplings, cover clips, supporting clips, ground clamps, and elbows as required; to comply with manufacturer's recommendations.

C. Outlets:

1. Provide bracket or device covers as required to support wiring devices indicated.
2. Wiring Devices and Device Plates: In accordance with Section 26 27 26, Wiring Devices.
3. Manufacturers:
   a. The Wiremold Co.
   b. Walker.

2.08 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Removable, screw type.

D. Rating: Indoor.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.
3. Square D.

2.09 NONMETALLIC WIREWAY

A. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.

B. Type: Fiberglass-enclosed, with removable cover.

C. Captivated, corrosion-resistant cover screws.

D. Oil-resistant gaskets.

E. Meet UL cold impact test to minus 35 degrees C.

F. Manufacturer: Hoffman.

2.10 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

B. Loading: AASHTO, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6- or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.

D. Drainage:

1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.

E. Raceway Entrances:

1. Provide on all four sides.
2. Provide knockout panels or precast individual raceway openings.
3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:

1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
2. Location:
   a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
   b. Floor: Centered below manhole or handhole cover.

G. Cable Racks:

1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
2. Wall Attachment:
   a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
   b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
   c. Arrange in order that spare raceway ends are clear for future cable installation.

H. Manhole Frames and Covers:

1. Material: Machined cast iron.
2. Diameter: 36-1/2 inch.
3. Cover Type: Indented, solid top design, with two drop handles each.
4. Cover Loading: AASHTO H-20.
5. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
   a. Above 600 Volts: Electric HV.
   b. 600 Volts and Below: Electric LV.
   c. Telephone.

I. Handhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, bolt-on, of nonskid design.
3. Cover Loading: AASHTO H-20.
4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
   a. 600 Volts and Below: ELECTRIC LV.
   b. TELEPHONE.

J. Hardware: Steel, hot-dip galvanized.

K. Manufacturers:

1. Utility Vault Co.
2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.

2.11 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
   a. Nonmetallic, interlocking, for multiple conduit sizes.
   b. Suitable for all types of conduit.
   c. Manufacturers:
      1) Underground Device, Inc.
      2) Carlon.
2. Template Type:
   a. Nonmetallic, custom made one-piece spacers.
   b. Suitable for all types of conduit.
   c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
   d. Conduit openings cut 1 inch larger than conduit outside diameter.
   e. Additional openings for stake-down, rebar, and concrete flow through as required.
   f. Manufacturer and Product: SP Products; Quik Duct.

B. Identification Devices:

1. Raceway Tags:
   a. Material: Permanent, nonferrous metal.
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 6 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
   f. Manufacturers and Products:
      1) Panduit; Type HTDU.
      2) Reef Industries; Terra Tape.
3. Buried Raceway Marker:
   a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
   b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
   c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.

C. Raceway Coating: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

D. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
   a. Raychem.
   b. 3M.

E. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 REUSE OF EXISTING CONDUITS

A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.

1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
2. Conduit is sized per the NEC.
3. Conduit is of the type specified in Contract Documents.
4. Conduit is supported as specified in Contract Documents.

B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.

E. Slabs and Walls (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.04 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch interior and exposed. Minimum 1 inch underground or embedded in concrete masonry. Minimum 2 inches in ductbanks.

B. Exterior, Exposed: PVC-coated rigid galvanized steel.

C. Interior, Exposed:

1. PVC-coated rigid galvanized steel.
2. Electrical metallic tubing for ceiling portion of lighting circuits in administration areas only.

D. Interior, Concealed (Not Embedded in Concrete):

1. PVC-coated rigid galvanized steel.
2. Electrical metallic tubing in administration areas only.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40, rigid galvanized steel for analog circuits.

F. Direct Earth Burial: PVC Schedule 80, rigid galvanized steel for analog circuits.

G. Concrete-Encased Ductbank: PVC Schedule 40, rigid galvanized steel for analog circuits.

H. Under Slabs-On-Grade: PVC Schedule 80, rigid galvanized steel for analog circuit.

I. Transition from Underground or Concrete Embedded to Exposed: Rigid galvanized steel.

J. Under Equipment Mounting Pads: PVC Schedule 80 conduit.

K. Exterior Light Pole Foundations: Rigid galvanized steel PVC-coated rigid

L. Corrosive Areas: PVC Schedule 80.

M. Hazardous Gas Areas: PVC-coated rigid galvanized steel.

3.05 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.
3. Wet or Corrosive Areas: Flexible nonmetallic, liquid-tight.
4. Dry Areas: Flexible, metallic liquid-tight.
5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.06 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

A. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance.

B. Apply heat shrinkable tubing to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

C. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

D. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
    a. Provide a watertight seal.
    b. Without Concrete Encasement: Install watertight entrance seal device on each side.
    c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
    d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
    e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air Conditioning Equipment:
    a. Penetrate equipment in area established by manufacturer.
    b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
    c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
4. Corrosive-Sensitive Areas:
    a. Seal all conduit passing through chlorine room walls.
    b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
    c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.

5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
    a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
    b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Manholes and Handholes:
    a. Metallic Raceways: Provide insulated grounding bushings.
    b. Nonmetallic Raceways: Provide bell ends flush with wall.
    c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.07 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze.

C. Application/Type of Conduit Strap:

1. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Wood: Wood screws.
2. Hollow Masonry Units: Toggle bolts.
3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
4. Steelwork: Machine screws.
5. Location/Type of Hardware:
    a. Dry, Noncorrosive Areas: Galvanized.
    b. Wet, Noncorrosive Areas: Stainless steel.
    c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.08 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide PVC-coated rigid steel conduits where direct buried.
3. Use manufacturer’s recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.09 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.

C. Install in accordance with manufacturer’s instructions.

3.10 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading.

3.12 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.13 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.

c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.

2. Rigid Galvanized Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at source enclosure.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
6. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
7. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.14 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:

1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: Rigid galvanized steel conduit.

I. Installation with Other Piping Systems:

1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: Along entire length, coat with raceway coating.

K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

L. Provide deflectional/expansion fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.

M. Concrete Encasement:

1. As specified in Section 03 30 00, Cast-in-Place Concrete.
2. Concrete Color: Red.

N. Backfill:

1. As specified in Section 31 23 23.15, Trench Backfill.
2. Do not backfill until inspected by Engineer.

3.15 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:

1. 3 inches clear between adjacent 2-inch or larger raceway.
2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
    a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.

2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Switch: Install on lock side of doors.
4. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
   a. Dimensions given to centerline of box.
   b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
   c. Do not straddle CMU block or other construction joints.
2. Light Switch:
   a. 48 inches above floor.
   b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet:
   a. 15 inches above floor.
   b. 6 inches above counter tops.
   c. Wall Mounted: 52 inches above floor.
5. Convenience Receptacle:
   a. General Interior Areas: 15 inches above floor.
   b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of splashback, or 6 inches above counter tops without splashback.
   c. Industrial Areas, Workshops: 48 inches above floor.
   d. Outdoor, All Areas: 24 inches above finished grade.
6. Special-Purpose Receptacle: 30 inches above floor or as shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 TELEPHONE AND DATA OUTLET

A. Provide empty 4-11/16-inch square, deep outlet box.

B. Provide blank single gang raised device cover if cables are not installed.

3.19 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grading has been determined.

C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.20 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.21 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin, destination, voltage and circuit number.
2. Install at each exposed terminus (switchgear, switchboard, MCC, junction boxes, pull boxes, instruments, control panels, power panels, lighting panels, disconnect switches, control stations, receptacles, light switches, etc.), near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
3. Provide nylon strap for attachment.

B. Warning Tape:

1. Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.
2. Install minimum of 24 inches of the ends of detectable warning tape inside nearest below grade manholes, and handholes.
3. Stub up a minimum of 24 inches of the ends of detectable warning tape at above grade where conduit transition from below grade to above grade, or at the exterior of building or structures where underground conduit go under the building structure slabs and footers.

C. Buried Raceway Marker:

1. Install at grade to indicate direction of underground raceway.
2. Install at bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.22 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touchup painted conduit threads after assembly to cover nicks or scars.

D. Touchup coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

SECTION 26 05 70
ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   c. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
   d. 1584, Guide for Performing Arc Flash Hazard Calculations.
3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70E, Standard for Electrical Safety in the Workplace.
5. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910 Subpart S, Electrical.

1.02 SUBMITTALS

A. Action Submittals Signed and Sealed by Professional Engineer (PE) in Tennessee:

1. Short circuit study.
2. Protective Device Coordination Study.
3. Arc flash study.
4. Arc flash warning labels.

1.03 QUALITY ASSURANCE

A. Short circuit and protective device coordination and arc flash studies shall be prepared by manufacturer furnishing motor control centers or a professional engineer (PE) registered in the State of Tennessee.

B. The short circuit, protective device coordination and arc flash studies shall be signed and sealed by a professional engineer (PE) registered in the State of Tennessee.

1.04 SEQUENCING AND SCHEDULING

A. Initial complete short circuit, protective device coordination and arc-flash studies shall be submitted and reviewed before Engineer will review Shop Drawings for overcurrent protective equipment. It is imperative that the electrical subcontractor begin this work immediately after award of the contract. This task requires extensive coordination and work with numerous Vendors. Failure of the electrical subcontractor to provide the initial complete short circuit study before any Shop Drawing for any overcurrent protective equipment will result in rejection of the Shop Drawing without review.

B. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 10 days before energizing electrical equipment.

C. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.

D. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

1.05 GENERAL STUDY REQUIREMENTS

A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on Drawings.

B. Perform studies using one of the following electrical engineering software packages:

1. SKM Power Tools for Windows.
2. ETAP.
3. Paladin.
4. Easy Power.

C. Perform complete fault calculations for each existing proposed and ultimate source combination.

1. Source combination may include present and future power company supply circuits, large motors, or generators. Obtain and verify with the Power Company in writing all information needed to conduct this study. Provide this correspondence and information including contacts and phone numbers with the Study Submittal.

D. Utilize proposed and existing load data for study obtained from Contract Documents and from field investigation of system configuration, wiring information, and equipment.

E. Existing System and Equipment:

1. Entire of existing system to be included in studies.
2. Include fault contribution of existing motors and equipment in study.
3. Include impedance elements that affect new system and equipment.
4. Include protective devices in series with new equipment.

F. Device coordination time-current curves for low voltage distribution system; include individual protective device time-current characteristics.

1.06 SHORT CIRCUIT STUDY

A. General:

1. Prepare in accordance with IEEE 399.
2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
4. Use cable and bus resistances calculated at 25 degrees C.
5. Use medium-voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation levels.
6. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN conductors.
7. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

B. Provide:

1. Calculation methods and assumptions.
2. Typical calculation.
3. Tabulations of calculated quantities.
4. Results, conclusions, and recommendations.
5. Selected base per unit quantities.
6. One-line diagrams.
7. Source impedance data, including electric utility system and motor fault contribution characteristics.
8. Impedance diagrams.
9. Zero-sequence impedance diagrams.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Electric utility's supply termination point.
2. Unit substations No. 5 and No. 6.
3. Motor control centers MCC-M1 and MCC-M2.
4. Manual transfer switch MTS-M1.
5. Adjustable frequency drives AFD-7-22-1, AFD-7-22-2, AFD-7-22-3.
6. All disconnect switches.
7. Branch circuit panelboard LP-M1.
8. Future load contributions as shown on one-line diagram.

D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.

E. Provide bolted line-to-line fault current study for areas as defined for three-phase bolted fault short circuit study.

F. Verify:

1. Equipment and protective devices are applied within their ratings.
2. Adequacy of unit substations and motor control centers bus bars to withstand short circuit stresses.
3. Adequacy of transformer windings to withstand short circuit stresses.
4. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

G. Tabulations:

1. General Data:
   a. Short circuit reactances of rotating machines.
   b. Cable and conduit material data.
   c. Bus data.
   d. Transformer data.
   e. Circuit resistance and reactance values.
2. Short Circuit Data (for each source combination):
   a. Fault impedances.
   b. X to R ratios.
   c. Asymmetry factors.
   d. Motor contributions.
   e. Short circuit kVA.
   f. Symmetrical and asymmetrical fault currents.

3. Equipment Evaluation:
    a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
    b. Maximum fault current available.

H. Written Summary:

1. Scope of studies performed.
2. Explanation of bus and branch numbering system.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of short circuit study.
6. Comments or suggestions.

I. Suggest changes and additions to equipment rating and/or characteristics.

J. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

K. Revise data for “as-installed” condition.

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.
    a. Provide separate curve sheets for phase and ground fault coordination for each scenario.
    b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
    c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
    d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
    e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Electric utility's relays.
2. Electric utility's fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
3. Medium-voltage equipment relays.
4. Medium-voltage and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
5. Low-voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
6. Pertinent transformer full-load currents at 100 percent.
7. Transformer magnetizing inrush currents.
8. Transformer damage curves; appropriate for system operation and location.
9. ANSI transformer withstand parameters.
10. Significant symmetrical and asymmetrical fault currents.
11. Motor overload relay settings for motors greater than 40 horsepower.
12. Ground fault protective device settings.
13. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.

C. Primary Protective Device Settings for Delta-Wye Connected Transformer:

1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within transformer's characteristics curve, including a point equal to 58 percent of IEEE C57.12.00 withstand point.
2. Secondary Line-to-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.

D. Separate medium voltage relay characteristics curves from curves for other devices by at least 0.4-second time margin.

E. Tabulate Recommended Protective Device Settings:

1. Relays:
   a. Current tap.
   b. Time dial.
   c. Instantaneous pickup.
   d. Electronic settings data file.
2. Circuit Breakers:
   a. Adjustable pickups.
   b. Adjustable time-current characteristics.
   c. Adjustable time delays.
   d. Adjustable instantaneous pickups.

e. I^2t In/Out.
f. Zone interlocking.
g. Electronic settings data file.

F. Written Summary:

1. Scope of studies performed.
2. Summary of protective device coordination methodology.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of coordination study.
6. Appendix of complete relay and circuit breaker electronic setting files.
7. Comments or suggestions.

1.08 ARC FLASH STUDY

A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.

B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.

C. Base Calculation: For each major part of electrical power system, determine the following:

1. Flash hazard protection boundary.
2. Limited approach boundary.
3. Restricted approach boundary.
4. Incident energy level.
5. Glove class required.

D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.

1. Bus name.
2. Bus voltage.

E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.
2. Upstream protective device name, type, and settings.
3. Bus line-to-line voltage.

F. Produce arc flash evaluation summary sheet listing the following additional items:

1. Bus name.
2. Upstream protective device name, type, settings.
3. Bus line-to-line voltage.
4. Bus bolted fault.
5. Protective device bolted fault current.
6. Arcing fault current.
7. Protective device trip/delay time.
8. Breaker opening time.
9. Solidly grounded column.
10. Equipment type.
11. Gap.
12. Arc flash boundary.
13. Working distance.
14. Incident energy.

G. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 40 cal/cm^2. Propose approaches to reduce energy levels.

H. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:

1. Equipment manufacturer's information used to prepare study.
2. Assumptions made during study.
3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.
4. Arc flash evaluations summary spreadsheet.
5. Bus detail sheets.
6. Arc flash warning labels printed in color on thermally bonded adhesive backed UV and weather-resistant labels.

PART 2 PRODUCTS

2.01 ARC FLASH WARNING LABELS

A. Arc flash warning labels printed in color on thermally bonded adhesive backed, UV- and weather-resistant labels. An example label is located following end of section in Figure 1.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Engineer in writing of required major equipment modifications.

D. Provide laminated one-line diagrams (minimum size 11 inches by 17 inches) to post on interior of electrical room doors.

E. Provide arc flash warning labels on equipment as specified in this section.

3.02 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this Specification:

1. Figure 1: Example Arc Flash Label.

END OF SECTION

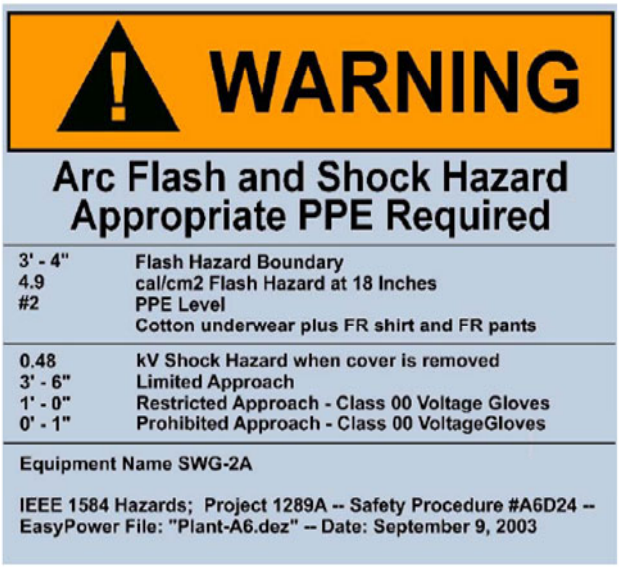


Figure 1
Example Arc Flash Label

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D877/D877M, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   b. D923, Standard Practices for Sampling Electrical Insulating Liquids.
   c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
   f. D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
   h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
   i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
   j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
2. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, Shielded Power Cables 5000V-4600V.
   b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
   c. S-97-682, Utility Shielded Power Cables Rated 5 through 46 kV.
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulation Resistance of Electric Machinery.
   b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.

c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above.
g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
h. C2, National Electrical Safety Code.
i. C37.20.1, Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear.
j. C37.20.2, Standard for Metal-Clad Switchgear.
k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
l. C37.23, Standard for Metal-Enclosed Bus.
m. C62.33, Standard Test Methods and Performance Values for Metal-Oxide Varistor Surge Protective Components.

4. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
   c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
5. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.
   d. 101, Life Safety Code.
7. National Institute for Certification in Engineering Technologies (NICET).
8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. Schedule for performing inspection and tests.
   c. List of references to be used for each test.
   d. Sample copy of equipment and materials inspection form(s).
   e. Sample copy of individual device test form.
   f. Sample copy of individual system test form.
2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
   a. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
   b. Staged sequence of initial energization of electrical equipment.
   c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
   d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test.
4. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
5. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
   a. Protective relays.
   b. Intelligent overload relays.
   c. Adjustable frequency drives.
   d. Power metering devices.
   e. Uninterruptible power supplies.
   f. Electrical communications modules.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.

2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test Instrument Calibration: In accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

1. Scheduled with Owner prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

C. Notify Owner at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

A. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by the short circuit, coordination and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.

B. Adjust mechanisms and moving parts of equipment for free mechanical movement.

C. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

D. Verify nameplate data for conformance to Contract Documents and approved Submittals.

E. Realign equipment not properly aligned and correct unlevelness.

F. Properly anchor electrical equipment found to be inadequately anchored.

G. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

H. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

I. Provide proper lubrication of applicable moving parts.

J. Inform Engineer of working clearances not in accordance with NFPA 70.

K. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

L. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required due to extensive damage, as determined by Engineer, refinish entire assembly.

M. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

A. Replace transformer insulating oil not in compliance with ASTM D923.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day:
    a. Submit Voltage Field Test Report within 5 days of test.
4. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.

3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in ON or CLOSED position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders: Destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbutton.
    c. Control switch.
    d. Pilot light.
    e. Control relay.
    f. Circuit breaker.
    g. Indicating meter.
10. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.
11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench or thermographic survey applied to bolted joints.
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees C, or less.

12. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature.
14. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor lugs and connections.
15. Exercise active components.
16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. With switches and breakers open.
    e. With switches and breakers closed.
    f. Control wiring except that connected to solid state components.
    g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Overpotential Tests:
    a. Applied ac or dc voltage and test procedure in accordance with IEEE C37.20.2, C37.20.3 and NEMA PB 2. Alternatively, use NETA ATS Table 100.2.
    b. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. Test results evaluated on a pass/fail basis.
3. Current Injection Tests:
    a. For entire current circuit in each section.
    b. Secondary injection for current flow of 1 ampere.
    c. Test current at each device.
4. Control Wiring:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational Test:
    a. Initiate control devices.
    b. Check proper operation of control system in each section.

3.04 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With switches and breakers open.
   e. With switches and breakers closed.
   f. Control wiring except that connected to solid state components.
   g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

3.05 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.

9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.06 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 6 and larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections for:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables for:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.

4. Control Cables for:
    a. Proper termination.
    b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:

1. Insulation Resistance Tests:
    a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
    b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
    c. Evaluate ohmic values by comparison with conductors of same length and type.
    d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

3.07 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
    c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Contact Resistance Tests:
    a. Contact resistance in microhms across each switch blade and fuse holder.
    b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.08 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
    a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
    b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
    c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
    d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
    a. Contact resistance in microhms across each pole.
    b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
    a. Long-time minimum pickup and delay.
    b. Short-time pickup and delay.
    c. Ground fault pickup and delay.
    d. Instantaneous pickup by run-up or pulse method.

e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.09 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer's instructions.
7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.

3.10 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
   a. Tight cover gasket and proper seal.
   b. Unbroken cover glass.
   c. Condition of spiral spring and contacts.
   d. Disc clearance.
   e. Condition of case shorting contacts if present.
2. Mechanically check each relay for:
   a. Freedom of movement.
   b. Proper travel and alignment.
3. Verify each relay:
   a. Complies with Contract Documents, approved Submittal, and application.
   b. Is set in accordance with recommended settings from Coordination Study.

B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.
2. Test on nominal recommended setting for:
   a. Pickup parameters on each operating element.
   b. Timing at three points on time-current curve.
   c. Pickup target and seal-in units.
   d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.

3.11 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
   c. Ratio and accuracy test.
2. Potential Transformer Tests:
   a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
   c. Ratio and accuracy test.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.12 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.13 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboards, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 3 ohm(s).
2. Two-Point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.25 ohm.

3.14 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.
   c. Neutral ground conductor is solidly grounded.
2. Verify control power has adequate capacity for system.

3. Manually operate monitor panels for:
   a. Trip test.
   b. No trip test.
   c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.15 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 hp and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
   e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
      1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.
5. Overpotential Tests:
   a. Applied ac or dc voltage and test procedure in accordance with IEEE C37.20.2, C37.20.3 and NEMA PB 2. Alternatively, use NETA ATS Table 100.2.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Test results evaluated on a pass/fail basis.
6. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.
7. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.
8. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.16 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.

4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in OFF or OPEN position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Pilot lights.
    e. Control relays.
    f. Circuit breakers.
    g. Indicating meters.
10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify current and potential transformer ratios conform to Contract Documents.
12. Check bus connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints or thermographic survey:
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees C, or less per NETA ATS Table 100.18.
13. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
14. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.

15. Verify performance of each control device and feature furnished as part of motor control center.
16. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
17. Exercise active components.
18. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of connections.
19. Compare overload heater rating with full-load current for proper size.
20. Compare motor protector and circuit breaker with motor characteristics for proper size.
21. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 100.1.
2. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer's published data.
    b. Investigate values in excess of 120 seconds.
3. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal board and each device terminal.
    c. Insulation resistance test at 1,000 volts dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.
4. Operational test by initiating control devices to affect proper operation.

3.17 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Check connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for proper operation:
   a. Manual transfer function switch.
   b. Generator under load and nonload conditions.
   c. Auto-exerciser of generator under load and no-load conditions.
5. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
   b. Phase-to-phase and phase-to-ground for 1 minute.
   c. Test values in accordance with manufacturer’s published data.
2. Contact Resistance Test:
   a. Contact resistance in microhms across each switch blade for both source positions.
   b. Investigate values exceeding 500 micro-ohms.
   c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Set and calibrate in accordance with Specifications, Manufacturer’s recommendations and Coordination Study:
   a. Voltage and frequency sensing relays.
   b. Time delay relays.
   c. Engine start and shutdown relays.
4. Perform automatic transfer tests by:
   a. Simulating loss of normal power.
   b. Return to normal power.
   c. Simulating loss of alternate power.
   d. Simulating single-phase conditions for normal and alternate sources.
5. Monitor and verify operation and timing of:
   a. Normal and alternate voltage sensing relays.
   b. Engine-start sequence.
   c. Timing delay upon transfer and retransfer.
   d. Engine cool down and shutdown.

e. Interlocks and limit switch functions.
f. Engine cool down and shutdown feature.

3.18 BATTERY SYSTEM

A. Visual and Mechanical Inspection:

1. Physical damage and electrolyte leakage.
2. Evidence of corrosion.
3. Intercell bus link integrity.
4. Battery cable insulation damage and contaminated surfaces.
5. Operating conditions of ventilating equipment.
6. Visual check of electrolyte level.

B. Electrical Tests:

1. Measure:
   a. Bank charging voltage.
   b. Individual cell voltage.
   c. Electrolyte specific gravity in each cell.
   d. Measured test values to be in accordance with manufacturer's published data.
2. Verify during recharge mode:
   a. Charging rates from charger.
   b. Individual cell acceptance of charge.
3. Load tests for integrity and capacity; test values in accordance with IEEE 450.

3.19 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground bus.

B. Electrical Tests:

1. Varistor Type Arrestors:
   a. Clamping voltage test.
   b. Rated RMS voltage test.
   c. Rated dc voltage test.
   d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

3.20 STANDBY AND EMERGENCY GENERATOR SYSTEMS

A. Visual and Mechanical Inspection:

1. Proper grounding.
2. Blockage of ventilating passageways.
3. Proper operation of jack water heaters.
4. Integrity of engine cooling and fuel supply systems.
5. Excessive mechanical and electrical noise.
6. Overheating of engine or generator.
7. Proper installation of vibration isolators.
8. Proper cooling liquid type and level.
9. Operate engine-generator and check for:
    a. Excessive mechanical and electrical noise.
    b. Overheating.
    c. Correct rotation.
    d. Check resistance temperature detectors or generator inherent thermal protectors for functionability and proper operation.
    e. Excessive vibration.
10. Verify voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
11. Proper operation of meters and instruments.
12. Compare generator nameplate rating and connection with one-line diagram or approved Submittal.
1. Verify engine-generator operation with adjustable frequency drives energized and operating under normal load conditions.

B. Electrical and Mechanical Tests:

1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
    a. Transfer switch operation.
    b. Automatic starting operation.
    c. Operating ability of engine-generator.
    d. Overcurrent devices capability to withstand inrush currents.
2. Phase rotation tests.
3. Test engine protective shutdown features for:
    a. Low oil pressure.
    b. Overtemperature.
    c. Overspeed.
4. Load bank test with resistors for each load step. Record voltage, frequency, load current, oil pressure, and engine coolant temperature at 15-minute intervals:
    a. 25 percent applied load for 30 minutes.
    b. 50 percent applied load for 30 minutes.
    c. 75 percent applied load for 30 minutes.

d. 100 percent applied load for 3 hours.
e. Load test results to demonstrate ability of unit to deliver rated load for test period.

5. One-Step Rated kW Load Pickup Test:
a. Perform test immediately after performing load bank test.
b. Apply rated load, minus largest rated hp motor, to generator.
c. Start largest rated horsepower motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.

3.21 UNINTERRUPTIBLE POWER SUPPLIES (UPS)

A. UPS Start-up Inspection and Testing:

1. Visual Inspection:
a. Inspect equipment for signs of damage.
b. Verify installation per Drawings.
c. Inspect cabinets for foreign objects.
d. Verify neutral and ground conductors are properly sized and configured per vendor requirements as noted in vendor drawings supplied with installation manuals or submittal package.
e. Inspect all battery cell cases.
f. Inspect each cell for proper polarity.

2. Mechanical Inspection:
a. Check all control wiring connections for tightness.
b. Check all power wiring connections for tightness.
c. Check all terminal screws, nuts, and spade lugs for tightness.

3. Electrical Inspection:
a. Check all fuses for continuity.
b. Confirm input bypass voltage and phase rotation is correct.
c. Verify control transformer connections are correct for voltages being used.
d. Assure connections and voltage of the battery string(s).
e. Battery inspection and certification according to IEEE standards.

4. Unit Start-Up:
a. Energize control power.
b. Perform control/logic checks and adjust to meet manufacturer specification.
c. Verify DC float and equalize voltage levels.
d. Verify DC voltage clamp and over-voltage shutdown levels.
e. Verify battery discharge, low-battery warning, and low-battery shutdown levels.
f. Verify fuse monitor alarms and system shutdown.

g. Verify inverter voltages and regulation circuits.
h. Verify inverter/bypass sync circuits and set overlap time.
i. Perform manual transfers and returns.
j. Simulate utility outage at no load.
k. Verify proper recharge.

B. Provide test instruments to record elapsed time between transfers, voltage, current, frequency, waveform, and transients.

1. Include services of an experienced technician to make final adjustments, final connections, and perform final testing.
2. Evidence of transients or phase shifts in graphs will be cause for rejection of system.

3.22 THERMOGRAPHIC SURVEY

A. Provide a thermographic survey per NETA ATS Table 100.18 of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:

1. Low voltage switchgear.
2. Low voltage motor control center.
3. Panelboard.

B. Provide a thermographic survey of feeder conductors No. 4 and larger terminating at:

1. Motors rated 50 hp and larger.
2. Low voltage disconnect switches.
3. Transfer switches.
4. Engine-generators.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading per NFPA 70B, Section 20.17.

E. Do not perform survey on equipment operating at less than 20 percent of rated load.

F. Utilize thermographic equipment capable of:

1. Detecting emitted radiation.
2. Converting detected radiation to visual signal.
3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.

G. Temperature Gradients:

1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
3. 16 degrees C and above indicates deficiency that is to be corrected immediately.

H. Provide written report of:

1. Areas surveyed and the resultant temperature gradients.
2. Locations of areas having temperature gradients of 3 degrees C or greater.
3. Cause of heat rise and actions taken to correct the cause of heat rise.
4. Detected phase unbalance.

END OF SECTION

SECTION 26 20 00
LOW-VOLTAGE AC INDUCTION MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. This section applies to low-voltage AC induction motors, whether or not referenced by a motor-driven equipment specification. If equipment specification section deviates from this section in requirements such as, application, horsepower, enclosure type, mounting, shaft type, or synchronous speed, then those listed requirements shall take precedence over this section.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.
   c. 841, Standard for Petroleum and Chemical Industry—Premium Efficiency Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C50.41, Polyphase Induction Motors for Power Generating Stations.
   c. MG 1, Motors and Generators.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 83, Standard for Safety for Thermoplastic-Insulated Wire and Cables.
   b. 674, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Standard for Safety for Overheating Protection for Motors.

1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

E. Inverter Ready Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Part 31.4.4.2.

F. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

G. ODP: Open drip-proof enclosure.

H. TEFC: Totally enclosed, fan-cooled enclosure.

I. TENV: Totally enclosed, nonventilated enclosure.

J. VPI: Vacuum pressure impregnated.

K. WPI: Open weather protected enclosure, Type I.

L. WPII: Open weather protected enclosure, Type II.

1.04 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.
3. Additional Rating Information:
    a. Service factor.
    b. Locked rotor current.
    c. No load current.
    d. Guaranteed minimum full load efficiency and power factor.
    e. Multispeed load classifications (e.g., variable torque).
    f. Adjustable frequency drive motor load classification (e.g., variable torque) and minimum allowable motor speed for that load classification.
4. Enclosure type and mounting (such as, horizontal, vertical).
5. Dimensions and total weight.

6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Bearing lubrication.
9. Bearing life.
10. Space heater voltage and watts.
11. Description, ratings, and wiring diagram of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.
13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture sensing system.

B. Informational Submittals:

1. Certified factory test reports.
2. Manufacturer's Certificate of Proper Installation.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric.
2. MagneTek.
3. Siemens Energy and Automation, Inc., Motors and Drives Division.
4. Baldor.
5. U.S. Electrical Motors.
6. TECO-Westinghouse Motor Co.
7. Toshiba International Corp., Industrial Division.
8. WEG Electric Motors Corp.
9. Siemens.
10. Marathon.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, use a single supplier to provide drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. For motors used in hazardous (classified) locations, Class I, Division 1, Groups B, C, and D, and Class II, Division 1, Groups E, F, and G provide motors that conform to UL 674 and have an applied UL listing mark.

E. Provide motors specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

F. Lifting lugs on motors weighing 100 pounds or more.

G. Operating Conditions:

1. Maximum ambient temperature not greater than 50 degrees C.
2. Provide motors suitable for operating conditions without reduction in nameplate rated horsepower or exceeding rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specification.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor): Driven equipment brake horsepower at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

2.04 SERVICE FACTOR

A. Inverter-Duty Motors: 1.0 at rated ambient temperature, unless otherwise noted.

B. Other Motors: 1.15 minimum at rated ambient temperature, unless otherwise noted.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60 Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specification:

Voltage Rating		
Size	**Voltage**	**Phase**
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3
450 hp and larger	4,000	3

C. Suitable for full voltage starting.

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

E. 50 hp and larger also suitable for reduced voltage starting with 65 or 80 percent voltage tap settings on reduced inrush motor starters.

2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency: NEMA premium efficiency.
2. Power Factor: High power factor.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower, if motor horsepower not covered by NEMA MG 1 tables.

B. Safe Stall Time: 12 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer’s standard winding insulation system.

B. Motors Rated Over 600 Volts: VPI windings in accordance with NEMA MG 1.

C. Three-Phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specifications, Class F with Class B rise at nameplate horsepower and designated operating conditions, except EXP and DIP motors which must be Class B with Class B rise.

2.09 ENCLOSURES

A. Conform to NEMA MG 1.

B. TEFC and TENV: Furnish with drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Groups C and D hazardous locations.

2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
4. Terminate thermostat leads in terminal box separate from main terminal box.

D. Submersible: In accordance with Article Special Motors.

E. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Article Special Motors.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19 and NFPA 70, Article 430:

Terminal Box Usable Values		
Voltage	**Horsepower**	**Percentage**
Below 600	15 through 125	500
Below 600	150 through 300	275
Below 600	350 through 600	225
Above 600	All sizes	200

E. Terminal for connection of equipment grounding wire in each terminal box.

F. Coordinate motor terminal box conduit entries versus size and quantity of conduits shown on Drawings.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:

1. 3/4 Horsepower and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.

2. 1 through 400 Horsepower: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and 11.

B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer's standard lubrication 100 horsepower and smaller.
   c. Oil lubricated 125 horsepower and smaller.
   d. Minimum 50,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer's standard bearing type.
   b. Manufacturer's standard lubrication 200 horsepower and smaller.
   c. Oil lubricated 250 horsepower and smaller.
   d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

1. Oil reservoirs with sight level gauge.
2. Oil fill and drain openings with opening plugs.
3. Provisions for necessary oil circulation and cooling.

E. Inverter Duty Rated Motors Larger than 50 hp, Bearing Isolation: Provide electrically isolated bearings to prevent stray current damage.

2.12 NOISE

A. Measured in accordance with NEMA MG 1.

B. Maximum Sound Level for Motors Controlled by Adjustable Frequency Drive Systems: 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

A. Protect Motor for Service Conditions:

1. ODP Enclosures: Indoor industrial atmospheres.
2. Other Enclosures: Outdoor industrial atmospheres, including moisture and direct sunlight exposure**.**

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

C. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen Over Air Openings: Corrosion-resistant on motors with ODP, WPI, and WPII enclosures meeting requirements for Guarded Machine in NEMA MG 1, and attached with stainless steel screws.

B. Winding Thermal Protection:

1. Thermostats:
   a. Motors for constant and adjustable speed application's 10 horsepower through 100 horsepower.
   b. Bi-metal disk or rod type thermostats embedded in stator windings.
   c. Automatic reset contacts rated 120 volts ac, 5 amps minimum, opening on excessive temperature. (Manual reset shall be provided at motor controller.)
   d. Leads extending to separate terminal box for motors 100 horsepower and larger.
2. Thermistors:
   a. Motors for constant and adjustable speed application's larger than 100 horsepower.
   b. Thermistor embedded in each stator phase winding before winding dip and bake process.
   c. In intimate contact with winding conductors.
   d. Epoxy-potted, solid state thermistor control module mounted in NEMA 250, Type 4X box on motor by motor manufacturer.
   e. Individual thermistor circuits factory-wired to control module.
   f. Control module rated for 120V ac power supply.
   g. Control module automatically reset contact for external use rated 120 volts ac, 5 amps minimum, opening on abnormally high winding temperature. Manual reset shall be provided at motor controller.

C. Space Heaters:

1. On motors 25 hp and larger, unless otherwise noted on equipment data sheets, provide winding space heaters with leads wired out to motor terminal box.
2. Provide extra hole or hub on motor terminal box as required.
3. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

D. Nameplates:

1. Raised or stamped letters on stainless steel or aluminum.
2. Display motor data required by NEMA MG 1, Paragraph 10.39 and Paragraph 10.40 in addition to bearing numbers for both bearings.
3. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

E. Anchor Bolts: Provide meeting manufacturer's recommendations and of sufficient size and number for specified seismic condition.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Chemical Industry, Severe-Duty (CISD-TEFC):

1. In accordance with IEEE 841.
2. TEFC in accordance with NEMA MG 1.
3. Suitable for indoor or outdoor installation in severe-duty applications including high humidity, chemical (corrosive), dirty, or salty atmospheres.
4. Motor Frame, End Shields, Terminal Box, and Fan Cover: Cast iron.
5. Ventilating Fan: Corrosion-resistant, nonsparking, external.
6. Drain and Breather Fittings: Stainless steel.
7. Nameplate: Stainless steel.
8. Gaskets between terminal box halves and terminal box and motor frame.
9. Extra slinger on rotor shaft to prevent moisture seepage along shaft into motor.
10. Double shielded bearings.
11. 125,000 hours minimum L-10 bearing life for direct-connected loads.
12. External Finish: Double-coated epoxy enamel.
13. Coated rotor and stator air gap surfaces.

14. Insulation System, Windings, and Connections:
    a. Class F insulation, Class B rise or better at 1.0 service factor.
    b. Multiple dips and bakes of nonhygroscopic polyester varnish.
15. Service Factor:
    a. At 40 Degrees C Ambient: 1.15.
    b. At 65 Degrees C Ambient: 1.00.
16. Safe Stall Time Without Injurious Heating: 20 seconds minimum.

C. Severe-duty Explosion-proof: Meet requirements for EXP enclosures and CISD-TEFC motors.

D. Severe-duty, Dust-ignition-proof: Meet requirements for DIP enclosures and CISD-TEFC motors.

E. Multispeed: Meet requirements for speeds, number of windings, and load torque classification indicated in motor-driven equipment specification.

F. Inverter Duty Motor:

1. Motor supplied power by adjustable voltage and adjustable frequency drives shall be inverter duty rated.
2. Suitable for operation over entire speed range indicated.
3. Provide forced ventilation where speed ratio is greater than published range for motor provided.
4. When installed in Division 1 hazardous (classified) location shall be identified as acceptable for variable speed when used in Division 1 location.
5. Shaft Grounding Device: Motors larger than 10 hp shall be provided with shaft grounding brush or conductive micro fiber shaft grounding ring. Shaft grounding device shall be solidly bonded to grounded motor frame per manufacturer's recommendations.
    a. Manufacturers:
        1) Grounding Brush: Sohre Turbomachinery, Inc.
6. Grounding Ring: EST-Aegis.

G. Inverter Ready Motor (Limited to specified HVAC Division equipment only):

1. Motor Supplied Power by Adjustable Voltage and Adjustable Frequency Drives: Inverter ready per NEMA Part 31.4.4.2.
2. Provide winding insulation rated 1,600 peak volts, minimum.
3. Meet or exceed NEMA MG 1 corona inception voltage rating.
4. Suitable for operation over entire speed range indicated.
5. When installed in Division 1 hazardous (classified) location, provide motor identified by manufacturer as suitable for use with a variable speed drive in a Division 1 location.

6. When installed in Division 2 hazardous (classified) location, provide motor identified by manufacturer as suitable for use with a variable speed drive in a Division 2 location.

H. Submersible Pump Motor:

1. Manufacturers:
   a. Reliance Electric.
   b. Xylem Flygt Corp.
2. At 100 Percent Load:
   a. Motors with Speeds Less than 1,200 rpm: Manufacturer's standard.
   b. Motors with Speeds 1,200 rpm and Greater:

Submersible Pump Motors		
Horsepower	**Guaranteed Minimum Efficiency**	**Guaranteed Minimum Power Factor**
5 through 10	80	82
10.1 through 50	85	82
50.1 through 100	87	82
Over 100	89	82

3. Insulation System: Manufacturer's standard Class B or Class F.
4. Motor capable of running dry continuously.
5. Enclosure:
   a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
   b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
   c. Seals: Tandem mechanical.
6. Bearing and Lubrication:
   a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
   b. Minimum 15,000 hours L-10 bearing life.
7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
8. Winding Thermal Protection:
   a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
   b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
   c. Switch contacts rated at 5 amps, 120V ac.

9. Motor Seal Failure Moisture Detection:
    a. Probes or sensors to detect moisture beyond seals.
    b. Probe or sensor monitoring module for mounting in motor controller, suitable for operation from 120V ac supply.
    c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120V ac contacts, one opening and one closing when flux of moisture is detected.
10. Bearing Overtemperature Protection for Motors Larger than 100 hp:
    a. Sensor on lower bearing housing monitoring bearing temperature.
    b. Any monitoring relay necessary to provide 120V ac contact opening on bearing overtemperature.
11. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
12. Connecting Cables:
    a. One cable containing power, control, and grounding conductors.
    b. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
    c. Length: 30 feet minimum.
    d. UL 83 listed and sized in accordance with NFPA 70.

I. Inclined Motors:

1. Motors suitable for operation only in horizontal position not acceptable.
2. Provide bearings designed for thrust imposed by driven equipment and by motor rotor when motor is in inclined position.
3. Provide lubrication system designed to provide adequate bearing lubrication when motor is in inclined position.

2.17 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
2. Routine (production) tests on all motors in accordance with NEMA MG 1. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency and power factor at 50, 75, and 100 percent of rated horsepower:
    a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, paragraph 12.59. and paragraph 12.60.
    b. For motors 500 horsepower and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
    c. On motors of 100 horsepower and smaller, furnish a certified copy of a motor efficiency test report on an identical motor.

B. Test Report Forms:

1. Routine Tests: IEEE 112, Form A-1.
2. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Table 12-9.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts.

3.02 MANUFACTURER'S SERVICES

A. Manufacturer's Certificate of Proper Installation.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Code of Federal Regulations (CFR): 10 CFR Part 431, DOE 2016 efficiency.
2. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
3. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. ST 20, Dry-Type Transformers for General Applications.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. Underwriters Laboratories, Inc. (UL):
   a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data, including efficiency.
4. Schematic and connection diagrams.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Test Report: Sound test certification for dry type power transformers (0 volt to 600 volt, primary).

3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

A. Efficiency: Meet or exceed values in Table 4.2 of NEMA TP 1.

B. Maximum Sound Level per NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.
3. 50 decibels for 51 kVA to 150 kVA.
4. 55 decibels for 151 kVA to 300 kVA.
5. 60 decibels for 301 kVA to 500 kVA.

C. Overload capability: Short-term overload per IEEE C57.96.

D. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

E. Vibration Isolators:

1. Rated for transformer’s weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

F. Manufacturers:

1. General Electric Co.
2. Square D Co.
3. Eaton/Cutler-Hammer.

2.02 MINI-POWER CENTER (MPC)

A. General: Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 1 enclosure.

B. Transformer:

1. Insulation Class and Temperature Rise: Manufacturer's standard.
2. Core and Coil: Encapsulated.
3. Full Capacity, 2-1/2 percent voltage taps, two above and two below normal voltage.
4. Primary Voltage: 480V, three-phase, unless otherwise shown.
5. Secondary Voltage: 240/120V single-phase, three-wire unless otherwise shown.

C. Panelboard: Full UL 489, short-circuit current rated.

1. Type: Thermal magnetic quick-make, quick-break, indicating, with noninterchangeable molded case circuit breaker.
2. Number and Breaker Ampere Ratings: 24-pole panelboard with 12-single pole, 20-ampere breakers and 6 double pole, 20-ampere breakers.

2.03 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.

B. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor Locations: NEMA 250, Type 3R.
6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps:

1. Single-Phase, 3 kVA to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 kVA to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 4.5 percent minimum on units 75 kVA and larger.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 30 kVA.

F. Isolation Transformer: Ground isolation shields to unit enclosure with conductor of same material, and same size minimum, as shield ground lead provided with unit.

END OF SECTION

SECTION 26 23 00
LOW-VOLTAGE SWITCHGEAR

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): C37.50, Switchgear—Low-Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
   b. C37.16, Standard for Preferred Ratings, Related Requirements, and Application Recommendation for Low-Voltage AC (635V and below) and DC (3200V and below) Power Circuit Breakers.
   c. C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
   d. C37.20.3, Standard for Metal Enclosed Interrupter Switchgear.
   e. C37.100, Standard Definitions for Power Switchgear.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories, Inc. (UL):
   a. 489, Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   b. 1558, Standard for Safety for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear.

1.02 SYSTEM DESCRIPTION

A. The low voltage switchgear shall be designed for open transition between the local utility, and the onsite generator.

B. The fully integrated mechanical and electrical components of the switchgear and generator set as a system, shall be designed so as to enable either a fully automatic mode of operation, or a fully manual system, that can be started, governed, and protected with safety shutdowns.

1.03 RELATED WORK SPECIFIED UNDER OTHER SECTIONS

Section	Item
26 05 70	Electrical Systems Analysis
26 08 00	Commissioning of Electrical Systems
26 32 13.13	Diesel Engine Generator Set and Engine Control Panel

1.04 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Operational description.
5. Anchoring instructions and details.
6. One-line, three-line, and control schematic Drawings.
7. Connection and interconnection Drawings, including interconnection with generator control panel specified in Section 26 32 13.13, Diesel Engine Generator Set and Engine Control Panel.
8. Circuit Breakers: Copies of time-current characteristics.
9. Ground Fault Protection: Relay time-current characteristics.
10. Bus data.
11. Incoming line section equipment data.
12. Transformer section equipment data.
13. Conduit entrance locations.

B. Informational Submittals:

1. Manufacturer’s installation instructions.
2. Certified Factory Test Report.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Manufacturer’s Certificate of Proper Installation as specified in Section 01 43 33, Manufacturer’s Field Services.

1.05 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 90 percent Project completion the following spare parts:

1. Power and Control Fuses: One complete set.
2. Indicating Lights: One complete set.
3. Paint: One pint, to match enclosure exterior finish in color and quality.
4. Indicating Lamp Pullers: Two each.
5. Indicating Lamp Resistors and Sockets: Two each.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric.
2. Westinghouse.
3. Siemens.
4. Square D.

2.02 GENERAL REQUIREMENTS

A. Service: 480 volts, three-phase, three-wire solid grounded wye having an available short circuit current at line terminals as shown on the Drawings.

B. Draw-out construction, designed and assembled in accordance with IEEE C37.20.1, IEEE C37.100, IEEE C37.50, NEMA 250, and UL 1558.

C. Switchgear and its major components shall be end products of one manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer’s services.

D. Provide arc flash reduction maintenance switches on all main and feeder breaker trip units in order to minimize the arc flash hazard category when in the maintenance setting. The maintenance switch shall set the circuit breaker trip setting to instantaneous with the no time delay for maintenance operations.

E. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment shall be fully rated without derating for operating conditions.

F. Lifting lugs on all equipment and devices weighing over 100 pounds.

G. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.03 STATIONARY STRUCTURE

A. Type: Metal-enclosed, draw-out circuit breaker switchgear construction, consisting of pull section with cable terminations, metering, breaker, transition, and auxiliary sections assembled to form a rigid, self-supporting, metal enclosed structure. Refer to Electrical Drawings for dimensions and layout.

B. Material: 11-gauge minimum cold-rolled steel, formed with reinforced steel members.

C. Grounded metal barriers between each breaker, main bus, branch cabling, and instrumentation/control.

D. Modular-designed steel frame with removable plates and individual, bolted, steel-framed vertical sections.

E. Individual, hinged doors over each breaker, metering, and auxiliary compartments.

F. Cable Installation and Termination Compartments:

1. Rear hinged doors, capable of being bolted closed.
2. Cable bending space in accordance with NFPA 70.
3. Cable supports in each vertical section.

G. Breaker Compartments:

1. Individual, grounded compartments, with:
   a. Sheet steel, top, bottom, sides, and ventilated compartment door with padlocking features.
   b. Flame retardant, arc track resistant nonmetallic rear barrier.
   c. Drawout rails, stationary breaker contacts, interlocks, and necessary control and indicating devices.

d. Shutters over all stationary contacts when breaker is in either TEST or full DISCONNECT position.
e. Padlocking provision on rackout rails for locking breaker in either TEST or DISCONNECT position.

2. Drawout Mechanism:
   a. Shall retain removable element in connected position.
   b. Mechanical interlocks to insure breaker is open before moved from any position, or when between positions.
   c. Four Distinct Breaker Positions: CONNECTED, TEST, DISCONNECTED, and WITHDRAW.
   d. Indicators to display breaker position.
   e. Capable of being operated without opening breaker door.
3. Breaker frame grounded to steel frame throughout travel of drawout mechanism.
4. Each compartment designed for specific breaker frame size.
5. Future breaker compartments fully equipped with all electrical connections, bolted metal barrier across compartment face, and compartment door.

H. Slide-Out Instrument Tray:

1. Mount above associated breaker.
2. Accessible from front of Switchgear.
3. For all control circuitry, breaker close and trip fuses, indicating lights, feeder metering, ammeter, rotary phase selector switch and other devices as shown on Drawings.

I. Auxiliary or transition sections equipped with devices shown on Drawings, auxiliary relays, potential transformers control transformers, fuses with hinged door over each compartment.

2.04 ENCLOSURE

A. Finish: Baked enamel applied over a rust-inhibiting, phosphated base coating.

1. Color:
   a. Exterior: Provide finish as approved by JEA.
   b. Interior: White.
   c. Unpainted Parts: Plated for corrosion resistance.

B. Indoor Enclosure:

1. NEMA 250, Type 1, with formed edges on hinged and nonhinged panels.
2. Rear, full-height, bolt-on panels for each enclosure section.
3. Cable Termination Access: Padlock provision.

4. Front and Rear Access:
   a. With service line and load terminations, internal devices, device and bolted bus connections serviceable from rear, and protective devices serviceable from front.
   b. Sections aligned across back and front with NFPA 70 required working space in front, back and sides.
5. Transition sections as required or as shown on the Drawings.
6. Side, rear and top covers: Removable, captive, screw-on plates with formed edges on each side.

2.05 BUSWORK

A. Material: Phase tin-plated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C.

B. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.

C. Brace for symmetrical short circuit currents as shown on Drawings.

D. Main Horizontal Bus: Nontapered, continuous current rating as shown on the Drawings.

E. Neutral Bus: Service entrance neutral pad at main breaker, furnish and install bonding jumper appropriately sized per NFPA.70.

F. Ground Bus:

1. Material: Tin-plate copper.
2. Rating: 33 percent minimum of main horizontal bus capacity.
3. Bolted to each vertical section.
4. Ground lug for 4/0 copper conductor on each end of bus.
5. Bus Connections and Joints: Bolted, with Belleville washers.

G. Extend each bus entire length of switchgear with provision for extension to future suctions.

2.06 PROTECTIVE DEVICES

A. Power Air Circuit Breakers:

1. All breakers in accordance with IEEE C37.13, IEEE C37.16, NEMA C37.50 and UL 489 Listed.
2. Arrangement: Fully rated main, generator, TIE and branch feeder circuit breakers, individually mounted draw-out when mounted in switchgear.

3. Three-pole electrically and mechanically trip-free with:
    a. Self-aligning primary and secondary contacts.
    b. Integral, solid state, over-current trip programmer.
    c. Arc quenchers.
    d. Closing Mechanism: Electrical.
    e. Stored energy mechanism with maximum five-cycle closing.
    f. Solid state trip device.
4. Individually mounted, drawout breaker listed for 100 percent continuous ampere rating.
5. Frame Size: As shown on Drawings.
6. Interrupting Rating: As shown on Drawings.
7. Main incoming breakers suitable for service entrance.

B. Electrical Operation:

1. Motor or solenoid automatic charging, plus manual charging.
2. Electrically closing, escutcheon mounted pushbutton with mechanical closing upon loss of control power.
3. Electrical trip, escutcheon mounted, trip pushbutton.
4. Control Power Voltage: 24V dc.
5. Charging motor or solenoid power voltage: 120V ac, internally supplied for switchgear.

C. Color-Coded Visual Indicators: Contacts OPEN and CLOSED, plus mechanism CHARGED and DISCHARGED.

D. Draw-Out Construction:

1. Individual compartments, sheet steel top, bottom and sides with padlockable door.
2. Flame retardant, arc track resistance nonmetallic rear barrier.
3. CTs, where shown, mounted within appropriate breaker compartment.
4. Stationary contacts extended to bus through rear barrier.
5. Secondary contact engagement maintained in CONNECTED and TEST positions.
6. Draw-out mechanism with disconnecting contacts, wheels and interlocks.
    a. Equipped with means to rack breaker into CONNECTED, TEST and DISCONNECTED positions.
    b. Full withdraw position allowing breaker removal.
    c. Door closable with breaker in any position.
7. External visual breaker position indicator.
8. Each compartment designed for specific breaker frame size.
9. Each breaker compartment fully equipped with electrical connections, bolted metal barrier across compartment face and compartment door.

E. Accessories:

1. Slow breaker closing handle for contact adjustments.
2. Breaker lifting hoist and travel rail on top of switchgear.
3. Auxiliary a/b contacts on main, generator and feeder breakers.
4. Shunt trip for main and generator breakers.
5. Padlocking provisions for lockout tagout, on each breaker.
6. Arc flash reduction maintenance switches.
7. Portable breaker lifter (dolly).
8. Mechanical interlock to prevent opening compartment door while breaker in CLOSED position.

F. Test Facilities:

1. Breakers to include integral external test points for portable test kit.
2. Handheld test kit for functional testing of trip circuitry of each breaker.

G. Solid State Trip Units: Flux-shift trip and current sensors.

1. Protective Programmers:
   a. Self-powered, automatic rms sensing micro-electronic processor.
   b. No external relays or accessories.
   c. Printed circuit cards with gold-plated contacts.
   d. Programmable Controls:
      1) Fixed-point, with repetitive accuracy and precise unit settings.
      2) Trip adjustments made by nonremovable, discrete step switching.
   e. Field-Installable Rating Plugs:
      1) Long-time pickup LED indicator and test receptacle.
      2) Matching load and cable requirements.
      3) Interlocked with tripping mechanism.
      4) Breaker to remain trip-free with plug removed.
      5) Keyed rating plugs to prevent incorrect application.
   f. Long-time pickup light.
   g. Selective coordination time/current curve shaping adjustable functions:
      1) Current setting.
      2) Long-time pickup.
      3) Long-time delay.
      4) Instantaneous pickup with short-time for all breakers.
      5) Short-time pickup for all breakers.
      6) Short-time delay for all breakers with I2T function, and IN-OUT switch.
      7) Ground fault pickup.

8) Ground fault delay with I2T function.
9) High instantaneous pickup with short-time delay.

h. Fault Trip Indicators: Mechanical push-to-reset type for overload and short circuit overload plus ground fault trip.
i. Rejection Pins: For each programmer frame size.

2. Phase Current Sensors:
   a. Multi-ratio type.
   b. Fixed, mounted on breaker frame.
   c. Molded epoxy construction.
   d. One toroidal type for each phase.
3. Ground Fault Sensor:
   a. Neutral bar single-ratio CT mounted in cable compartment.
   b. Molded epoxy construction.
   c. Shorting bar.
4. Portable Test Set: AC/DC static, full function unit for checking programmers' time-current characteristics of programmer.

2.07 CONTROL WIRING

A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power/current circuits.

B. Shielded cable rated 600 volts for transducer output and analog circuits.

C. Enclosed in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.

D. Conductor Lugs: Preinsulated, self-locking, spade type, with reinforced sleeves.

E. Identification: Individually, with permanent wire markers at each end.

F. Splices: Not permitted in switchgear wiring.

2.08 TERMINAL BLOCKS

A. Enclosed in steel wiring troughs.

B. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.

C. Shorting type for current transformer leads.

D. Provide terminal blocks for:

1. Conductors connecting to circuits external to switchgear.
2. Internal circuits crossing shipping splits.
3. Equipment parts requiring replacement and maintenance.

E. Spare Terminals: Not less than 20 percent.

F. Group terminal blocks for external circuit wiring leads.

G. Maintain 6-inch minimum space between columns of terminal blocks.

H. Identification: Permanent, for each terminal and columns of terminals blocks.

I. Manufacturer: General Electric; Type EB-5.

2.09 TEST FACILITIES

A. Breakers with integral external test points for portable test kit.

B. Handheld test kit for functional testing of trip circuitry of each breaker.

2.10 INSTRUMENTATION AND METERING

A. Potential Transformers:

1. Type: Molded.
2. Accuracy Classification: 0.3 at burden imposed by meters and instruments, including future.
3. Primary Fuses: Two, current-limiting.
4. Secondary Fuses: Two, current-limiting.

B. Current Transformer:

1. Type: Molded donut.
2. Accuracy: 0.3 at burden imposed by meters and instruments.
3. Shorting type terminal boards for current transformer leads.

2.11 POWER METER

A. Solid state device with LED displays and compartment door-mounted keypad.

B. Direct voltage input up to 600 volts ac.

C. Current input via current transformer with 5-ampere secondary.

D. Programmable current and potential transformer ratios.

E. Programmable limits to activate up to four alarms.

F. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.

G. Communications: Factory wired with two fixed ports for Ethernet/IP interface with SCADA system and for simultaneous connection to a field laptop computer. Use of add-on port expanders are not acceptable. Locate port for field connection on exterior of compartment door. Provide the following data exchange via Ethernet/IP interface with the SCADA system.

1. Data exchange:
   a. Volts, three-phase and phase to neutral.
   b. Amperes, three-phase and phase to neutral.
   c. Kilowatts.
   d. Kilowatthours.
   e. Power factor.
   f. Frequency.
   g. kVA.
   h. kVA.
   i. Individual and total current and voltage harmonic distortion.
2. Provide a data exchange look-up table to be used by the PICS supplier for collection and reading data from the power monitor.

H. Simultaneous Display:

1. Volts, three-phase and phase to neutral.
2. Amperes, three-phase and phase to neutral.
3. Kilowatts.
4. Kilowatthours.
5. Power factor.
6. Frequency.
7. kVA.
8. kVAR.
9. Individual and total current and voltage harmonic distortion.

I. Voltage Rating: 95 to 135 ac.

2.12 AUTO THROW OVER (ATO) CONTROLS

A. General: PLC based control module to sense utility and generator power and open and close main, tie and generator circuit breakers as shown on Drawings and report status to plant PLC.

B. Programmable Logic Controllers (PLC):

1. Solid state units capable of performing same function as conventional relays, timers, counters, drum sequencers, arithmetic, and other special functions necessary to perform required control functions.
2. Memory: 512 kb, minimum. Size processor such that there is a minimum of 30 percent spare memory available.
3. Minimum of 24 discrete inputs and 24 discrete outputs, optical isolations rated at 2,500-volt rms. Discrete outputs shall be rated for 2 amps at 120V ac. Each input and output shall have an LED ON/OFF status indicator.
4. Minimum of 25 percent excess capacity for inputs, outputs, internal coils, registers, and other necessary functions.
5. Capable of operating in a hostile industrial environment (for example, heat, electrical transients, RFI, and vibration) without fans, air conditioning, or electrical filtering. Units operate from 0 to 60 degrees C and up to 95 percent humidity, noncondensing.
6. Communications: Provide chassis mounted communications modules.
   a. Ethernet/IP communication module.
7. Manufacturers: Allen-Bradley.

C. The Auto Throw Over (ATO) System shall be designed for the following modes of control operation:

1. Automatic.
2. Off.
3. Test.
4. Manual.

D. A four-position selector switch (AUTS) shall be provided for selecting any of the operational modes specified above. When the AUTS switch is locked in the off position, the generator cannot be operated or started. The Auto, Test, and Manual modes of operation are specified as follows:

1. AUTS in “Automatic” Position: When the AUTS switch is in AUTO position the generator system shall be set for automatic operation, and open transition load assumption and return. Normal Condition being Main Breakers M1 and M2 are CLOSED. Tie-breakers T1 and T2 are OPEN. Generator Breaker G1 is OPEN. There are four different scenarios within the automatic operation as follows:
   a. When one Utility source fails:
      1) When one UTILITY source fails, and the AUTS switch is in the “automatic” position, OPEN the main breaker (M1 or M2) of the failed source and lock this breaker in the OPEN position, until such time that the PLC calls for CLOSING the breaker.

2) When confirmation is received at the PLC that main breaker (M1 or M2) is OPEN, the PLC issues a START engine command to the generator, and also a CLOSE command to Tie-breaker (T1 or T2). The engine "START" command shall be a contact closure sent to the locally mounted engine control panels (ECPS).
3) CLOSE the generator output circuit breaker G1 after the generator reaches operating voltage and frequency.
4) The engine generator shall be loaded from the plant PLC until it has assumed the entire bus ("A" or "B") load. During operation the generator control system shall regulate the output power of the engine generator so that it never exceeds the actual feeder loads connected to bus ("A" or "B").

b. When both UTILITY sources fail:
1) When both UTILITY sources fail M1 and M2, and the AUTS switch is in the "automatic" position, OPEN both main breakers M1 and M2 of the failed sources and lock these breakers in OPEN position until such time that the PLC calls for CLOSING these breakers.
2) When confirmation is received at the PLC that main breakers M1 and M2 are OPEN, the PLC issues a START engine command to generator, and also a CLOSE command to Tie-breakers T1 and T2. The engine "START" command shall be a contact closure sent to the locally mounted engine control panels (ECPS).
3) CLOSE the generator output circuit breaker G1after the generator reaches operating voltage and frequency.
4) The engine generator shall be loaded from the plant PLC until it has assumed entire bus "A and B" loads.

c. When one Utility Source returns:
1) When the UTILITY source returns, and the AUTS switch is in the "automatic" position, after a predetermined time, the PLC shall initiate an "Open transition return to the utility" sequence as described in the following steps:
a) Tie-breaker T1 (or T2) shall open. When confirmation is received at the PLC that tie-breaker T1 (or T2) is OPEN, the PLC issues a CLOSE command to Main breaker M1 (or M2).
b) Generator breaker G1 shall OPEN and the generator shall run for an adjustable cool down period of 5 to 40 minutes before shutdown.

d. When both Utility Sources return:
   1) When the both UTILITY sources return, and the AUTS switch is in the "automatic" position, after a predetermined time, the PLC shall initiate an "open transition return to the utility" sequence as described in the following steps:
      a) Tie-breakers T1 and T2 shall open. When confirmation is received at the PLC that tie-breakers T1 and T2 are OPEN, the PLC issues a CLOSE command to Main breakers M1 and M2.
      b) Generator breaker G1 shall open and the generator shall run for an adjustable cool down period of 5 to 40 minutes before shutdown.

2. AUTS in "Test" Position:
   a. A four-position LOAD selector switch shall be provided for selection between Bus "A", Bus "B", Both Buses "A" and "B", or No Load.
   b. When the AUTS is in the "Test" position, the LOAD selector switch is in the NO-LOAD position, the following test shall be preformed:
      1) When the operator enters a "start" signal at the PLC operator interface panel, implement the following sequence:
         a) Issue START command to generator. The engine START command is a contact closure to the locally mounted engine control panel (ECP).
         b) Verify that the two Tie breakers (TI and T2) are open. Close generator breaker (G1), bring the generator bus (Bus 'C') up to operating voltage and frequency. At this point the generator shall be running at no load, at Bus "C".
      2) When the operator enters a "stop" signal through the PLC operator interface panel, G1 shall open and the generator shall be shut down following an adjustable cool down period.
   c. When the AUTS is in the "Test" position, the LOAD selector switch is in the Bus "A" position, the following test shall be preformed:
      1) When the operator enters a "start" signal at the PLC operator interface panel, implement the following sequence:
         a) OPEN the main breaker M1 and lock this breaker in the OPEN position, until such time that the PLC calls for CLOSING the breaker.
         b) Issue START command to generator. The engine START command is a contact closure to the locally mounted engine control panel (ECP).

c) Verify that the two Tie breakers (TI and T2) are open, and main breaker M1 is open. Close generator breaker (G1), bring the generator bus (Bus 'C') up to operating voltage and frequency.
d) After the generator bus has reached operating voltage and frequency, Close tie breaker T1.

2) When the operator enters a "stop" signal through the PLC operator interface panel, implement the following sequence:
a) Tie-breaker T1 shall open. When confirmation is received at the PLC that tie-breaker T1 is OPEN, the PLC issues a CLOSE command to Main breaker M1.
b) Generator breaker G1 shall open and the generator shall run for an adjustable cool down period of 5 to 40 minutes before shutdown.

d. When the AUTS is in the "Test" position, the LOAD selector switch is in the Bus "B" position, the following test shall be preformed:

1) When the operator enters a "start" signal at the PLC operator interface panel, implement the following sequence:
a) OPEN the main breaker M2 and lock this breaker in the OPEN position, until such time that the PLC calls for CLOSING the breaker.
b) Issue START command to generator. The engine START command is a contact closure to the locally mounted engine control panel (ECP).
c) Verify that the two Tie breakers (TI and T2) are open, and main breaker M2 is open. Close generator breaker (G1), bring the generator bus (Bus 'C') up to operating voltage and frequency.
d) After the generator bus has reached operating voltage and frequency, Close tie breaker T2.

2) When the operator enters a "stop" signal through the PLC operator interface panel, implement the following sequence:
a) Tie-breaker T2 shall open. When confirmation is received at the PLC that tie-breaker T2 is OPEN, the PLC issues a CLOSE command to Main breaker M2.
b) Generator breaker G1 shall open and the generator shall run for an adjustable cool down period of 5 to 40 minutes before shutdown.

e. When the AUTS is in the "Test" position, the LOAD selector switch is in the Both Bus "A" and Bus "B" position, the following test shall be preformed:
   1) When the operator enters a "start" signal at the PLC operator interface panel, implement the following sequence:
      a) OPEN the main breakers M1 and M2 and lock these breakers in the OPEN position, until such time that the PLC calls for CLOSING these breakers.
      b) Issue START command to generator. The engine START command is a contact closure to the locally mounted engine control panel (ECP).
      c) Make sure that the two Tie breakers (TI and T2) are open and main breakers (M1 and M2) are open. Close generator breaker (G1), bring the generator bus (Bus 'C') up to operating voltage and frequency.
      d) After the generator bus has reached operating voltage and frequency, Close tie breakers T1 and T2.
   2) When the operator enters a "stop" signal through the PLC operator interface panel, implement the following sequence:
      a) Tie breakers T1 and T2 shall open. When confirmation is received at the PLC that tie-breakers T1 and T2 are OPEN, the PLC issues a CLOSE command to Main breakers M1 and M2.
      b) Generator breaker G1 shall open and the generator shall run for an adjustable cool down period of 5 to 40 minutes before shutdown.

3. AUTS in "Manual" Position: When this switch is in Manual position the entire operation is strictly manual (open transition) bypassing the PLC and utilizing the backup electromechanical system to implement the following functions (MANUALLY):
   a. Start generator system.
   b. Close the generator breaker.
   c. OPEN utility main breakers.
   d. CLOSE tie-breakers.
   e. The entire OPEN transition assumption of load and return to utility shall be manually feasible. Provide all safety interlocks for safe manual operation. The main, tie and generator circuit breakers shall be electrical interlocked to prevent parallel connection of the two incoming sources and the two incoming sources with the generator.
   f. In manual mode, individual breaker control switch (CS), engine control switches (ECS), speed controls, and voltage adjusting rheostats shall be used to perform required functions.

E. Plug-in, industrial grade interfacing relays with dust covers.

F. Plug-in printed circuit boards for sensing and control logic.

G. Adjustable solid state undervoltage sensors for all three phases of utility and of standby source:

1. Pickup 85 to 100 percent nominal.
2. Dropout 75 to 98 percent of pickup setting.

H. Adjustable frequency sensors for standby source:

1. Pickup 90 to 100 percent nominal.
2. Dropout 87 to 89 percent of pickup setting.

I. Control module with adjustable time delays:

1. 0.5- to 6-second engine start delay.
2. 0- to 5-minute load transfer to emergency delay.
3. 0- to 30-minute retransfer to normal delay.
4. 0- to 30-minute unload running time delay.
5. Switch to bypass any of the above time delays during testing.

J. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.

K. Exerciser, adjustable in 15-minute increments, 7-day dial clock to automatically exercise generator without load transfer and simulate normal power failure and transfer load to generator, complete with door mounted NO LOAD and LOAD selector switch.

L. Accessory Power: From 24V dc UPS integrally mounted and powered from the switchgear and backup 24V dc from generator batteries to ensure that control power is available to the microprocessor and protective device accessories. Refer to the P&ID drawings for additional interface requirements.

M. Switchgear network communication:

1. Switchgear ATO PLC and power meters shall be equipped with communication interface to allow remote monitoring from the Plant SCADA system.
2. Communication shall be Ethernet/IP.
3. The switchgear shall provide a single point of interface with the SCADA system. Provide necessary communication card for single point interface with SCADA. Any communication card required shall be factory installed, wired and tested by vendor.
4. All communication cabling shall be factory installed, connected and factory tested.

5. Coordinate data exchange from the ATO PLC and power meters to the Plant Control System with PICS subcontractor.
    a. Specified data shall be mapped into user map variables to optimize communications. Data shall include, but not be limited to:
        1) From each Power meter:
            a) Volts, three-phase and phase to neutral.
            b) Amperes, three-phase and phase to neutral.
            c) Kilowatts.
            d) Kilowatthours.
            e) Power factor.
            f) Frequency.
            g) kVA.
            h) kVAR
            i) Individual and total current and voltage harmonic distortion.
        2) Related to Generator:
            a) Running.
            b) Fuel Level.
            c) Leak.
            d) Low Battery.
        3) Related to Switchgear:
            a) Utility Power OK.
            b) Emergency Power Available.
            c) In Utility Power Position.
            d) In Emergency Power Position.
            e) Each breaker’s position.
    b. Provide PIC subcontractor with the network address of all device and mapping of data in the device at least two week prior to factory testing of the switchgear. Mapping shall use tags used on single-line diagrams.
6. Communication within switchgear shall be configured so network is not lost when a device is removed from the system.

2.13 EQUIPMENT IDENTIFICATION

A. Master Nameplate:

1. Deep-etched aluminum with manufacturer’s name and model number.
2. Riveted to main vertical section.

B. Section Identification:

1. Engraved metallic, riveted to each vertical section.
2. Serial number, bus rating, and section reference number.
3. Size: Manufacturer's standard.

C. Nameplate:

1. Engraved, acrylic for each circuit breaker cubicle and door mounted device.
2. White with black block type characters.
3. Character Height: 1/4 inch.
4. Size: Manufacturer's standard.
5. Inscriptions: As shown on one-line diagram.
6. Blank plates for future spaces.
7. Attachment Screws: Stainless steel panhead.

D. Cubicle Labels:

1. Nonmetallic, applied inside each cubicle compartment.
2. Device serial number, rating, and description.
3. Size: As required.

E. Metering Instruments: Meter type identified on meter face below pointer or dial.

F. Control Switches: Deep-etched, aluminum escutcheon plate.

G. Relays and Devices:

1. Stamped metallic, riveted to instrument case.
2. Manufacturer's name, model number, relay type, and rating data.

H. Switchgear Signs:

1. Two signs on front switchgear.
2. Size: Manufacturer's standard.
3. Engraved, acrylic.
4. Color: Red with white.
5. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
6. Characters: Gothic type, 2 inches high.
7. Attachment: Four rivets each sign.

2.14 KEY INTERLOCKS

A. The main, tie and generator circuit breakers shall be electrical interlocked to prevent parallel connection of the two incoming sources and the two incoming sources with the generator. (interlocking through the PLC only will not be acceptable).

1. Interlocks shall prevent:
   a. CLOSING tie breaker T1 unless main breaker M1 is OPEN.
   b. CLOSING tie breaker T2 unless main breaker M2 is OPEN.
   c. CLOSING generator breaker G1 unless both main breakers (M1 and M2) are CLOSED and both tie breakers (T1 and T2) are OPEN.
   d. CLOSING generator breaker G1 unless both main breakers (M1 and M2) are OPEN.
   e. CLOSING generator breaker G1 unless main breaker M1 is CLOSED and tie breaker T1 is OPEN, and main breaker M2 is OPEN.
   f. CLOSING generator breaker G1 unless main breaker M2 is CLOSED and tie breaker T2 is OPEN, and main breaker M1 is OPEN.

2.15 SURGE PROTECTIVE DEVICE

A. As specified in Section 26 43 00, Surge Protective Devices.

2.16 FACTORY TESTING

A. Factory Testing:

1. Applicable Standards: ANSI/IEEE C37.20.1.
2. Perform standard factory inspection and tests in accordance with ANSI and NEMA requirements to verify components have been designed to specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specifications.
5. Control Circuits and Devices:
   a. Energize circuit at rated voltage.
   b. Operate control devices.
   c. Perform continuity check.

6. Instruments, Meters, Protective Relays, and Equipment:
   a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
   b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers. Tests shall be made phase-to-phase and phase to around with 60-cycle test voltages applied for 1 second at 2,640 volts.
8. Verify equipment passed tests and inspection.
9. Provide standard factory inspection and test checklists and final certified and signed test report.
10. As part of the factory test, the internal data link shall be tested and checked out using a laptop/test PLC with appropriate software and interfaces installed.
11. The test laptop/PLC, hardware and software shall be furnished by switchgear vendor.
12. Submit a factory test plan for approval which includes data exchange table for SCADA communication testing. An approved test plan is a prerequisite to conducting factory testing.
13. Submit a factory test plan for approval which includes data exchange table for SCADA communication testing. An approved test plan is a prerequisite to conducting factory testing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to mounting pads with anchor bolts.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Job Site or classroom as designated by JEA for minimum person-days listed below, travel time excluded:

1. 3 person-days for installation assistance and inspection.
2. 3 person-days for functional and performance testing.
3. 1 person-day for prestartup classroom or Jobsite training.

4. 3 person-days for plant startup.
5. 1 person-day for post-startup training.
6. 2 person-days for joint Ethernet/IP data exchange testing for all switchgear with PICS.

B. Furnish startup services and training of JEA's personnel at such times as requested by JEA.

C. Provide Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Services.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. 289, Application Guide for Ground Fault Circuit Interrupters.
   c. KS 1, Enclosed Switches.
   d. PB 1, Panelboards.
   e. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL):
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Ground-Fault Circuit-Interrupters.
   h. 1699, Standard for Arc-Fault Circuit-Interrupters.
5. Institute of Electrical and Electronics Engineers (IEEE):
   a. C62.1, Surge Arresters for Alternating Current Power Circuits.
   b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.

3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   b. Provisions for future protective devices.
   c. Space for future protective devices.
   d. Voltage, frequency, and phase ratings.
   e. Enclosure type.
   f. Bus and terminal bar configurations and current ratings.
   g. Provisions for circuit terminations with wire range.
   h. Short circuit current rating of assembled panelboard at system voltage.
   i. Features, characteristics, ratings, and factory settings of auxiliary components.
   j. Wiring and schematic diagrams detailing control wiring, and differentiating between manufacturer-installed and field-installed wiring.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's recommended installation instructions.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton/Cutler-Hammer.
2. General Electric Co.
3. Square D Co.
4. Siemens.

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 24 19, Low-Voltage Motor Control.

2.02 GENERAL

A. Provide low voltage panelboards for application at 600V or less in accordance with this Section including panelboards installed in other equipment specified in Section 26 24 19, Low-Voltage Motor Control.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous” or “100 percent”, selected components and protective devices shall be rated for continuous load current at value shown.

A. Short Circuit Current Rating (SCCR): Equipment short circuit rating for each panelboard assembly shall be fully rated at the indicated SCCR on the Drawing or the following:

1. Minimum SCCR at 208Y/120 or 120/240 volts shall be 22,000 amperes rms symmetrical, unless otherwise shown on Drawings.
2. Minimum SCCR at 480Y/277 volts shall be 42,000 amperes rms symmetrical, unless otherwise shown on Drawings.

2.03 OVERCURRENT PROTECTIVE DEVICES

A. Overcurrent Device Mounting and Arrangement: Design panelboards to accommodate device installation and replacement without disturbing adjacent devices and without removing main bus.

B. Overcurrent Protective Devices: In accordance with NEMA KS 1, UL 98, and UL 489. Protective devices shall be adapted to panelboard installation.

C. Provisions for Future Overcurrent Device:

1. Provide space, mountings and bus connections such that like device may be installed without additional hardware.
2. Panel openings shall be closed with individual removable cover for each provision for future device.
3. Unless otherwise indicated, “spaces” in panelboards shall be fully equipped provision for future like devices.
4. Provisions for future devices shall be suitable devices rated no less than 60 amperes.

D. Protective Device Locking: Furnish provisions for handle padlocking for main, subfeed, and branch devices where indicated.

E. Branch Protective Devices:

1. Locking: Furnish devices with provisions for handle padlocking.
2. Load Connections: Wire lugs shall be mechanical or crimp compression type, removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
3. Provide a nameplate for each circuit, blanks for spares.

2.04 CIRCUIT BREAKERS

A. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.

B. Noninterchangeable: In accordance with NEC.

C. Bus Connection: Bolt-on circuit breakers in all panelboards.

D. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.

E. Unacceptable Substitution:

1. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
2. Do not use tandem or dual circuit breakers in normal single-pole spaces.

F. Specialty Breakers: Where indicated, provide breakers with the following features:

1. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
   a. Ground fault sensor shall be rated same as circuit breaker.
   b. Push-to-test button.
   c. Reset button.

G. Solid State Trip Units: Where indicated, equip breakers with solid state trip units in accordance with Section 26 14 13, Switchboards.

1. Long (Time) Short (Time) Instantaneous (LSI): Electronic trip unit with fixed long-time trip, adjustable short-time trip and delay, and adjustable instantaneous trip settings.
2. Long (Time) Short (Time) Instantaneous Ground (Fault) (LSIG): Electronic trip unit as above and also with adjustable ground fault trip and delay settings.

2.05 ENCLOSURES

A. General:

1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Type 1, Type 3R, and Type 3S material code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Provide surface-mount panelboard from trim with same dimensions as box front.
4. Finish: Rust inhibitor prime followed by manufacturer’s standard gray baked enamel or lacquer.

B. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Secure front trim to box with concealed trim clamps.
2. Overlap flush panelboards front trims with box nominal 3/4 inch on all sides.
3. Provide door in panelboard front trim, with concealed hinges, to access protective device operating handles.
4. Provide multi-point latching for doors over 30 inches in height.
5. Door Lock: Secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
6. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.

C. Multi-Section Panelboards: Where more than one section is required, provide multiple panelboard sections with separate fronts.

1. Sections shall be suitable for individual mounting to be field interconnected to form a single electrical unit.
2. Recessed-mount sections of the same panel shall all have the same size tubs and flush covers.
3. Surface-mount multi-section panelboards may be comprised of sections of unequal heights.
4. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard. Unless otherwise indicated, provide feed-through lugs on each section but last.
5. Provide neutral and ground terminal bars in each section.

2.06 BUSSING AND TERMINAL BARS

A. Bus:

1. Material: Tin-plated copper full sized throughout length.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

B. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors, and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.

C. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.
4. Oversize Neutral: Provide oversized neutral terminal bus as indicated.

D. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.07 SPECIAL FEATURES

A. General: Where indicated on Drawings or schedules, provide special features as specified.

1. Service Equipment Approval: Labeled for use as service equipment for panelboards having service disconnecting means.
2. Isolated Equipment Ground Terminal Bar:
   a. Provide in addition to equipment ground terminal bar specified above.
   b. Insulated from box.
   c. Provide individual conductor termination points equal to quantity of breaker pole positions plus all feeder, subfeed, and feed-through isolated ground conductors.
3. Controls:
   a. Provide controls in accordance with UL 508.
   b. Controls shall be Class I, 120V ac.
   c. Control circuits shall be protected by fuse or circuit breaker.
4. Extra Gutter Space: Dimensions and arrangement indicated.
5. Gutter Barrier: Arranged to isolate section of gutter as shown.
6. Subfeed: Protective device or lugs indicated, with additional terminals on neutral and ground bus to accommodate feeder.
7. Feed-Through Lugs: At opposite end of phase bus from mains, with additional terminals on neutral and ground buses, sized to accommodate feeders indicated.
8. Double Main Lugs: Furnish additional terminals on neutral and ground buses, sized to accommodate feeders indicated.

B. Surge Arresters:

1. Comply with Section 26 43 00, Transient Voltage Suppression.
2. Coordinate impulse sparkover voltage with system voltage.
3. Provide protective device within panelboard as disconnecting means and short circuit protection per manufacturer’s recommendation.

C. Provide factory mounting within panelboard utilizing UL-recognized mounting device. Provide panelboard circuit breaker for TVSS.

2.08 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed devices; also provide for branch devices where indicated.

B. Multi-Section Panelboards: Where more than 42 poles are required or more than one section is otherwise indicated, provide multiple panelboards with separate fronts.

1. Panelboard sections shall be individually installed and field interconnected to form a single electrical unit.
2. Unless otherwise indicated, provide feed-through lugs on each section but last.
3. Surface-mount panels shall be individually mounted and may be different sizes.
4. Recessed-mount panels shall be individually mounted and the same size tub and flush cover.
5. Surface-mount multi-section panelboards may be comprised of sections of unequal heights.
6. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard.
7. Provide neutral and ground terminal bars in each section.

C. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Front trim shall be secured to box with concealed trim clamps.
2. Surface-mount panelboard front trim shall have same dimensions as box.
3. Flush panelboards front trims shall overlap box nominal 3/4 inch on all sides.
4. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.
5. Doors over 30 inches in height shall have multi-point latching.
6. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
7. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.
8. Hinged Front Cover (Door In Door): Entire front trim hinged to surface box with standard door within hinged trim cover.

2.09 POWER DISTRIBUTION PANELBOARDS

A. Branch Protective Devices:

1. Locking: Furnish devices with provisions for handle padlocking.
2. Load Connections: Wire lugs shall be mechanical or crimp compression type, removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
3. Provide a nameplate for each circuit, blanks for spares.

PART 3 EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1, and manufacturers' written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties.

G. Mount flush panels uniformly flush with wall finish.

H. Provide typewritten circuit directory for each panelboard.

I. In addition to conduit or nipples otherwise required for feeder and branch circuit wiring between multi-section panelboard sections, provide nipples for branch circuits two trade sizes larger than required for installed branch circuit wires or an empty 2-inch nipple, or a 1-1/4-inch trade size conduit if tubs are more than 24 inches apart.

J. Provide engraved identification for each protective device.

3.02 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification.

1. Panelboard Schedule.

END OF SECTION

SECTION 26 24 19
LOW-VOLTAGE MOTOR CONTROL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which shall be followed for this section:

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. American National Standard Institute (ANSI): C2, National Electrical Safety Code (NESC).
   b. C37.20.7, Guide for Testing Metal Enclosed Switchgear Rated up to 38 kV for Internal Arcing Faults.
2. National Electrical Contractors Association (NECA): 402, Standard for Installing and Maintaining Motor Control Centers.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
   b. ICS 1, Industrial Control and Systems: General Requirements.
   c. ICS 2, Controllers, Contactors, and Overload Relays Rated 600 Volts.
   d. ICS 2.3, Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600V.
   e. ICS 18, Motor Control Centers.
   f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 98, Enclosed and Dead-Front Switches.
   b. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 845, Motor Control Centers.

1.02 DEFINITIONS

A. LCD: Liquid Crystal Display.

B. N.C.: Normally Closed.

C. N.O.: Normally Open.

D. SPD: Surge Protection Device.

E. VT: Voltage Transformer.

1.03 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Front Panel Elevations.
5. Conduit entrance locations.
6. Bus data.
7. Protective Devices: Copies of time-current characteristics.
8. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
9. Anchoring instructions and details.
10. Anchoring instructions and details.
11. Typed Tabulation:
    a. Motor name; tag (equipment) numbers as shown on Drawings.
    b. Motor horsepower.
    c. Nameplate full load current.
    d. Measured load current and voltage.
    e. Overload model number and setting.
    f. Protective device trip settings.
    g. Manufacturer’s solid state starter switch or dip switch or program settings.
    h. Attach above typed, tabulated data to a copy of starter manufacturer’s overload relay or setting selection tables for starters provided.
12. Control diagrams.
13. One-line diagrams.
14. Schematic (elementary) diagrams.
15. Outline diagrams.
16. Interconnection diagrams.
17. Operational description.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s installation instructions.
3. Factory test reports, certified.

1.04 QUALITY ASSURANCE

A. Provide products manufactured within scope of UL that conform to UL Standards and have applied UL Listing Mark.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping Splits: Established by the electrical subcontractor to facilitate ingress of equipment to final installation location within building.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide materials, equipment, and accessories specified in this section manufactured by:

1. Eaton Electrical/Cutler-Hammer.
2. GE Industrial Systems.
3. Schneider Electric/Square D Services.
4. Allen-Bradley.
5. Siemens.

2.02 GENERAL

A. Make adjustments necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

B. Controllers: NEMA ICS 1, NEMA ICS 2, Class A.

C. Control Transformer:

1. Two winding, 120-volt secondary, primary voltage to suit.
2. Two current-limiting fuses for primary circuit.
3. One fuse in secondary circuit.
4. Mount within starter unit.
5. Minimum rating 500 vA.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Lifting lugs on equipment and devices weighing over 100 pounds.

F. Anchor Bolts: Type 316 stainless steel, and as specified in Section 05 50 00, Metal Fabrications. Seismic Zone and Importance Factor shall be as specified in Section 01 61 00, Common Product Requirements.

G. Seismic Zone and Importance Factor: As specified in Section 01 61 00, Common Product Requirements.

H. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Altitude: Zero feet.
3. Equipment to be fully rated.

I. Enclosures: In accordance with NEMA 250.

J. Equipment Finish:

1. Electrocoating process applied over rust-inhibiting phosphated base coating.
2. Exterior Color: Manufacturer's standard.

2.03 SEPARATELY MOUNTED MOTOR CONTROL

A. Manually Operated Starter, Fractional Horsepower:

1. Rating: Horsepower rated to maximum of 10 horsepower at 600 volts with overload protection.
2. Single- or three-phase, nonreversing, full voltage.
3. Control: As shown.
4. Enclosure: As shown.
5. Locking in OFF position.
6. Two spare auxiliary, field-changeable contacts.

B. Manually Operated Starter, Integral Horsepower:

1. Rating: Horsepower rated to maximum of 10 horsepower at 600 volts with overload protection.
2. Single- or three-phase, nonreversing, full voltage.
3. Control: As shown.
4. Enclosure: As shown.
5. Locking in OFF position.
6. Two spare auxiliary, field-changeable contacts.

C. Combination Full-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for 22,000 amperes at 480-volts short circuit capacity with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: As shown.
4. Disconnect Type: Motor circuit protector.
5. Enclosure: As shown.
6. Padlockable operating handle, capable of up to three locks.

D. Combination Two-Speed Motor, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for 22,000 amperes at 480-volts short circuit capacity with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: As shown.
4. Disconnect Type: Motor circuit protector.
5. Suitable for two-speed, two winding motors.
6. Enclosure: As shown.
7. Pilot Lights: As shown.
8. Padlockable operating handle, capable of up to three locks.

E. Thermal Motor Overload Protection:

1. Inverse-time-limit characteristic.
2. Heater: Bimetallic overload, adjustable trip, or directly heated melting alloy, ratchet principle type element.
3. Relay Trip.
4. Manual reset.
5. Provide in each ungrounded phase.
6. Mount within starter unit.

F. Solid State Motor Overload Protection:

1. Inverse-time-limit characteristic.
2. Phase loss, phase unbalanced and Class II ground fault protection.
3. Current operated electronic circuitry with adjustable trip.
4. Class 10/20/30 relay trip, switch selectable.
5. N.O. auxiliary contact for remote monitoring.
6. Manual reset.
7. Provide in each ungrounded phase.
8. Mount within starter unit.

2.04 MOTOR CONTROL CENTERS

A. General:

1. New sections and starter units shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 18, and UL 845.
2. Voltage Rating: As shown.
3. Short Circuit Rating: 65,000 amperes rms symmetrical at 480 volts for entire motor control center as a complete assembly.
4. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.

5. NEMA ICS 18, Part 3:
   a. Class: II.
   b. Type: B.
   c. Provide blank spaces on interconnection diagrams to add control conductor code designations during installation of equipment.
   d. Motor control centers shall communicate with the plant PLC system. Several interface connections are required between the plant PLC system and the MCCs, refer to Drawings for connections requirements. Power Monitors, Solid state overloads/motor management systems and adjustable frequency drives shall have network connections. Refer to Specification Section 40 90 00, Instrumentation and Control for Process Systems for additional communication and coordination requirements.

B. Enclosure:

1. Type: NEMA 250, Type 1, indoor gasketed.
2. Vertical Section Indoor Dimensions for NEMA 1 Type: 90 inches high, 20 inches wide, 21 inches deep, nominal. Alternative width dimensions of 24 inches and 30 inches are acceptable for oversize devices or panels. Do not exceed space shown.
3. Construction:
   a. Sheet steel reinforced with channel or angle irons.
   b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
   c. Removable top cover plates and bottom cover plates.
   d. Removable plates on end panels for future bus extension.
4. Section Mounting: Removable formed-steel channel sills and lifting angles.
5. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
6. Vertical Wiring Compartment: Full height, isolated from unit starters with separate hinged door and tie supports. No terminal blocks allowed in vertical wireway compartment.
7. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
8. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
9. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
10. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.
11. Cable Entrance: Main leads enter from top control and feeder circuits enter from top.

C. Bus:

1. Horizontal Power Bus:
   a. Three-phase tin-plated copper non-tapered, entire width of control center, rated amperes as indicated.
   b. Silver-plated at joints.
   c. Construct to allow future extension of additional sections.
   d. Isolated from tap horizontal wireway.
   e. Provide Belleville washers on bus connection belts.
   f. Current rating: as shown on Drawings.
2. Vertical Power Bus:
   a. Three-phase, tin plated copper, full height of section, rated 300 amperes minimum.
   b. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   c. Insulated and isolated barrier, complete with automatic shutters over stub openings.
3. Neutral Bus: None.
4. Ground Bus: Tin plated copper, bare, entire width of control center.
5. Bus Bracing: Amperes rms symmetrical, as shown.

D. Motor Controller Unit:

1. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Construction:
   a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.
   b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 6 and larger.
   c. Readily interchangeable with starters of similar size.
3. Starters:
   a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
   b. Rating: Horsepower rated at 600 volt, UL labeled for 65,000 amperes at 480 volts short circuit capacity with overload protection or as shown on Drawings.
   c. Three-phase, nonreversing, unless specified otherwise.
   d. Disconnect Type: Motor circuit protector.
   e. Combination Full Voltage, Magnetic Starter:
      1) Control: As shown.

f. Combination Reduced Voltage, Solid State Starter:
   1) Control: HAND/OFF/AUTO selector switch; STOP/START pushbutton as shown on Drawings.
   2) Bypass contactor.
   3) Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
   4) Kick start, with adjustable torque and time settings.
   5) Ramp start, selectable current or torque, and adjustable time.
   6) Smooth stop ramp, adjustable time.
   7) Phase loss unbalance and phase reversal protection.
   8) LED display or LCD of fault, N.O. contact to communicate fault condition.
g. Combination Adjustable Frequency Drive, Solid State Starter: Drives as specified in Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.
h. Communications: PROFIBUS-DP.
i. Padlockable operating handle when de-energized with up to three-lock capability.
j. Unit door interlocked to prevent opening when disconnect is in closed position.
k. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
l. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

4. Disconnecting Device:
   a. As indicated.
   b. Padlockable in OPEN position for up to three locks.
5. Circuit Breaker:
   a. Meet requirements of NEMA AB 1 and UL 489.
   b. Molded case with manufacturer’s recommended trip setting for maximum motor protection.
   c. Thermal-magnetic trip or magnetic trip only as shown.
   d. Tripping indicated by operating-handle position.
   e. Interrupting capacity required for connection to system with short circuit capacity indicated.
6. Fused Switch:
   a. Heavy-duty, motor rated, load-break, quick-make, quick-break type meeting requirements of UL 98 and NEMA KS 1.
   b. Current-limiting fuses, with rejection clips.
7. Load Detector Relay:
   a. Manual reset with adjustable differential.
   b. Manufacturer:
      1) Cutler-Hammer; Type D60LA.
      2) Allen-Bradley;Bulletin 2100.

8. Thermal Motor Overload Protection:
   a. Inverse-time-limit characteristic.
   b. Heater: Bimetallic overload, adjustable trip, or directly heated melting alloy, ratchet principle type element.
   c. Relay Trip: Quick, Class 10.
   d. Manual reset.
   e. Provide in each ungrounded phase.
   f. Mount within starter unit.
9. Solid State Motor Overload Protection:
   a. Inverse-time-limit characteristic.
   b. Phase loss, phase unbalance and Class II ground fault protection.
   c. Current operated electronic circuitry with adjustable trip.
   d. Class 10/20/30 relay trip, switch selectable.
   e. One N.O. auxiliary contact for remote monitoring.
   f. Manual reset.
   g. Provide in each ungrounded phase.
   h. Mount within starter unit.
   i. Communications: PLC, as specified in MCC Network communication
10. Motor Thermal Protector Interface: Manual-reset interposing relay for connection to motor-mounted thermal protector system.
11. Ground Fault Protection: Where indicated and as specified in Paragraph Main Protective Device and Feeder Units, except provide instantaneous operation device.
12. Capacitor Connection: Terminals to allow easy connection of power factor correction capacitors on source side of starter overload relays on starters where capacitor connection is shown.

E. Control Unit:

1. Disconnecting Device: Pull-apart terminal blocks capable of de-energizing external source control circuits in unit.
2. Control Devices: As indicated and as specified in Section 26 05 04, Basic Electrical Materials and Methods.
3. Control Wiring:
   a. Copper, 14 AWG, minimum.
   b. Permanent sleeve type markers with wire numbers applied to each end of wires.
   c. Terminate wires using insulated locking fork or ring type crimp terminals.
   d. Terminate current transformer leads on shorting type terminal blocks.

F. Incoming Line Terminal:

1. Construction: As specified in Paragraph, Motor Controller Unit.
2. Incoming Service Feeder: As shown on Drawing.
3. Mechanical type CU-/AL lugs for 75 degrees C cable.

G. Main Protective Device and Feeder Unit:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable. As shown.
3. Solid State Trip Circuit Breaker:
   a. In accordance with UL 489.
   b. Main and tie protective device and feeder protective devices 100 amp and larger.
   c. UL labeled as suitable for service entrance as shown.
   d. Fixed mounted insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
   e. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.
   f. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
   g. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.
4. Molded Case Circuit Breaker:
   a. In accordance with UL 489.
   b. Feeder protective device less than 100 amps.
   c. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
   d. Indicate tripping by operating-handle position.
   e. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
5. Ground Fault Protection:
   a. Suitable for 480-volt, three-phase, three-wire, solidly grounded wye system.
   b. Ground sensors to encircle phase conductors where used, and connected to ground relays with adjustable pickup settings and time-current characteristics indicated.
   c. Circuit breaker shunt trip and relay operating from fused 120-volt ac control source within control center.
6. Key Interlocking: Kirk keying system with Master lock cylinders and keys where indicated.
7. Phase Monitoring Relay:
   a. Three-phase monitoring relay to protect against low voltage, voltage unbalance, and phase reversal.
   b. Manufacturer and Product: Schneider Electric/Square D; Class 8430 Type MPS or Class 8430 Type MPD.

H. Digital Instruments:

1. Digital Power Meter: As specified in Section 26 09 13, Power Measurement and Control.
2. Digital Monitoring Panel:
   a. Microprocessor-based electronic monitoring package, complete with keypad or entry keys.
   b. Monitors and Display Parameters for MCC Starters and Contactors:
      1) Status: ON, OFF, tripped, no response.
      2) Location or address.
      3) Control voltage.
      4) Overload alarm.
      5) Cause of device trip.
      6) Operations count.
      7) Run time.
      8) Set points.
      9) Starter description and identification.
   c. Alpha numeric, LED display or LCD.
   d. Communications: Interface capability to starters, power meter, and computer.
   e. Manufacturers and Products:
      1) Cutler-Hammer.
      2) General Electric.
3. Ground Detection Lights: Heavy-duty oiltight type, with operation explanation nameplate.

I. Key Interlocks:

1. Two Main and One Tie Breaker Arrangement:
   a. Two keys available for each group of three locks.
   b. Two out of three breakers closed at any time.

J. MCC Network Communication:

1. Each power monitor, motor starter, adjustable frequency drive and power meter shall be equipped with communication interface to allow remote monitoring and control of the motor from the Plant PLC system.
2. The motor control center shall provide multiple points of interface with the PLC system, refer to drawings. Provide necessary communications cards for required interface points with PLC. All MCC mounted power monitors, starters and AFDs shall communicate to the plant control system via these PLC interface connections. Any communication card required shall be factory installed, wired and tested by vendor.
3. All communication cabling shall be factory installed, connected and factory tested.

4. Coordinate data exchange from the power monitors, drives and starters to the Plant Control System with PICS subcontractor.
    a. Data noted on Instrumentation and Control Legend Sheet 1, Drawing, shall be mapped into user map variables to optimize communications.
    b. Data noted above for the power monitors shall be mapped into user map variables to optimize communications.
    c. Data noted on motor control diagrams shall be mapped into user map variables to optimize communications.
    d. Data to be mapped on each device is displayed on motor control diagrams.
        1) Data found in multiple motors shall be mapped to the same location in user map variables. For example, the motor running status shall appear in the same mapping location for all motors.
    e. Provide PIC subcontractor with the network address of all device and mapping of data in the device at least two week prior to factory testing of the MCC. Mapping shall use tags used on motor control diagrams. For example, LSL for level switch low.
5. Communication within MCC shall be configured so network is not lost when a starter or drive is removed from the system.

K. SPD: As specified in Section 26 43 00, Surge Protection Devices.

L. Transformers: As specified in Section 26 22 00, Low-Voltage Transformers.

M. Panelboards: As specified in Section 26 24 16, Panelboards.

N. Capacitors: As specified in Section 26 05 04, Basic Electrical Materials and Methods.

O. Pushbuttons, Indicating Lights, Selector Switches, Elapsed Time Meters, Control Relays, Time-Delay Relays, and Reset Timers: As specified in Section 26 05 04, Basic Electrical Materials and Methods.

P. Nameplates:

1. Laminated plastic; white, engraved to black core.
2. Provide for each motor control center and each unit.
3. Engrave with inscription shown on single-line diagram.
4. Provide blank nameplates on spaces for future units.
5. Attach with stainless steel panhead screws on face of control center.

Q. Space Heaters: Thermostatically controlled. Locate in bottom of each vertical section for operation from 120-volt power source derived internal to MCC.

2.05 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part VIII.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to Specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specification.
5. Control Circuits and Devices:
   a. Energize circuit at rated voltage.
   b. Operate control devices.
   c. Perform continuity check.
6. Instruments, Meters, Protective Relays, and Equipment:
   a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
   b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers.
   a. Tests: Phase-to-phase and phase-to-around with 60-cycle test voltages applied for 1 second at 2,640 volts.
8. Verify equipment passed tests and inspection.
9. Provide standard factory inspection and test checklists, and final certified and signed test report.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with NEMA ICS 2.3, IEEE C2, NECA 402, Submittals, and manufacturer’s written instructions and recommendations.
2. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.
3. Install equipment plumb and in longitudinal alignment with pad or wall.
4. Coordinate terminal connections with installation of secondary feeders.

5. Grout mounting channels into floor or mounting pads.
6. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.
7. Motor Data: Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
   a. Motor served by tag number and equipment name.
   b. Nameplate horsepower.
   c. Motor code letter.
   d. Full load amperes.
   e. Service factor.
   f. Installed overload relay catalog number.

B. Circuit Breakers:

1. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
2. Adjust to approximately 11 times motor rated current.
3. Determine motor rated current from motor nameplate following installation.

C. Thermal Overload Relay:

1. Select and install overload relays and apply settings after actual nameplate full-load current rating of motor has been determined.
2. Initial Settings: In accordance with manufacturer's recommendation.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at jobsite or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, and inspection of installation.
2. 1/2 person-day for functional and performance testing.
3. 1/2 person-day for plant startup.
4. 1 person-day for training of Owner's personnel.
5. 2 person-days for joint PLC data exchange testing for all MCCs with PICS.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. Federal Specifications (FS):
   a. W-C-596, General Specification for Connector, Electrical, Power.
   b. FW-S-896F/GEN, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. WD 1, General Requirements for Wiring Devices.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL):
   a. 498, Standard for Attachment Plugs and Receptacles.
   b. 508, Standard for Safety for Industrial Control Equipment.
   c. 943, Standard for Ground-Fault Circuit-Interrupters.
   d. 1449, Standard for Transient Voltage Surge Suppressors.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s product data for wiring devices.

PART 2 PRODUCTS

2.01 SWITCHES

A. Switch, General Purpose:

1. NEMA WD 1 and FS W-S-896F/GEN.
2. Totally enclosed, ac type, with quiet tumbler switches and screw terminals.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contacts.
4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.

5. Rating: 20 amps, 120/277 volts.
6. Color:
   a. Office Areas: White.
   b. Other Areas: Brown.
7. Automatic grounding clip and integral grounding terminal on mounting strap.
8. Manufacturers and Products, Industrial Grade:
   a. Arrow Hart; 1201/2221 Series.
   b. Bryant; 4801/4901 Series.
   c. Hubbell; 1202/1222 Series.
   d. Leviton; 1201/1221 Series.

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. Enclosure/Mounting and Rating:
   a. General Purpose:
      1) Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. UL 508 listed.
      2) General Purpose Rating: 30 amperes, 600V ac.
      3) Minimum Motor Ratings:
         a) 2 hp for 120V ac, single-phase, two-pole.
         b) 3 hp for 240V ac, single-phase, two-pole.
         c) 15 hp for 480V ac, three-phase, three-pole.
      4) Screw-type terminals.
   b. Explosion-Proof:
      1) Provide enclosed manual motor starter-type. Three-pole nonreversing contactor.
      2) Minimum Motor Rating: 10 hp, 480V ac, three-phase, three-pole.
      3) Enclosure: NEMA 250, Type 7.
      4) Provide lockable external handle operator.
3. Manufacturers:
   a. General Purpose:
      1) Bryant.
      2) Hubbell.
   b. Explosion-Proof: Eaton, Type B101.

2.02 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596.

2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
7. Size: For 2-inch by 4-inch outlet boxes.
8. Industrial Grade:
    a. Color:
        1) Office Areas: White.
        2) Other Areas: Brown.
    b. Manufacturers and Products:
        1) Arrow Hart; 5262/5362 Series.
        2) Bryant; 5262/5362 Series.
        3) Hubbell; 5262/5362 Series.
        4) Leviton; 5262/5362 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacles.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Color: Ivory.
4. Standard Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
5. Feed-Through Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
6. Manufacturers:
    a. Bryant.
    b. Hubbell.
    c. Arrow Hart.
    d. Leviton.

C. Receptacle, Corrosion-Resistant.

1. Meet requirements of general-purpose receptacles.
2. Nickel coated metal parts.
3. Color: Yellow.
4. Manufacturer and Product:
    a. Hubbell; 52CM62/53CM62.
    b. Leviton; 52CM-62/53CM-62.

D. Receptacle, Special-Purpose:

1. Rating and number of poles as indicated or required for anticipated purpose.
2. One matching plug with cord-grip features for each special-purpose receptacle.

E. Receptacle, Explosion Proof:

1. UL listed.
2. Dead front, interlocked, circuit breaking.
3. Electrical Ratings: 20 amps, 125 volts.
4. Hazardous Area Ratings: NEMA 7BCD, 9FG.
5. Provide matching plug with each receptacle.
6. Manufacturers and Products:
   a. Crouse-Hinds; Ark Guard 2, Series ENR.
   b. Appleton; U-Line.
   c. Killark; Series UGR/UGP.

2.03 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Plastic:

1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
2. Color: To match associated wiring device.
3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:

1. Material: Malleable ferrous metal, or aluminum with gaskets.
2. Screw: Oval-head stainless steel.

E. Sheet Steel:

1. Finish: Zinc electroplate.
2. Screws: Oval-head stainless steel.

3. Manufacturers:
   a. Appleton.
   b. Crouse-Hinds.

F. Engraved:

1. Character Height: 3/16-inch.
2. Filler: White.

G. Weatherproof:

1. Receptacles, Weatherproof Type 1:
   a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
   b. Mounting Screw and Cap Spring: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; Type WLRD-1.
      2) Appleton; Type FSK-WRD.
2. Receptacles, Weatherproof Type 2:
   a. UL listed for WET location while in use.
   b. Die cast metal cover.
   c. Locking type.
   d. Manufacturers and Products: TayMac; Type Multi-Mac.
3. Switches:
   a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
   b. Mounting Screw: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; DS-181 or DS-185.
      2) Appleton; FSK-1VTS or FSK-1VS.

H. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel boxes.

I. Sheet Steel: Formed sheet steel or Feraloy designed for installation on cast metal boxes.

PART 3 EXECUTION

3.01 SWITCHES

A. Switch, General Purpose:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position.

3. Install single-pole, two-way switches so toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position so toggle is in up position when ON.
3. Install within sight of motor when used as a disconnect switch.

3.02 RECEPTACLES

A. Duplex Receptacles:

1. Install with grounding slot up, except where horizontal mounting is shown, in which case install with neutral slot down.
2. Ground receptacles to boxes with grounding wire only.
3. Weatherproof Receptacles:
   a. Install in cast metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose Receptacles: Install in accordance with manufacturer’s instructions.

3.03 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Engrave with designated titles.

F. Types (Unless Otherwise Shown):

1. Office: Metal.

2. Exterior:
    a. Switch: Weatherproof.
    b. Receptacle in DAMP location: Weatherproof Type 1.
    c. Receptacle in WET location: Weatherproof Type 2.

G. Interior:

1. Flush Mounted Boxes: Metal.
2. Surface Mounted, Metal Boxes:
    a. General Purpose Areas: Sheet Steel.
    b. Other Areas: Cast.
3. Surface Mounted, Aluminum Boxes:
    a. General Purpose Areas: Stamped.
    b. Other Areas: Cast aluminum.
4. Surface Mounted, Sheet Steel Boxes: Raised sheet steel.
5. Surface Mounted, Nonmetallic Boxes: Manufacturer's standard.
6. Receptacle shown as Weatherproof on Drawings: Weatherproof Type 1.

END OF SECTION

SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

1.02 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source inverter.
4. EMU: Energy monitoring unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.
9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.
13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.

14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor logic.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. This Specification covers supply, installation, testing and commissioning of Adjustable Frequency Drives. As a minimum, all drives 75 hp and larger shall be 18-pulse, and 74 hp and less shall be 6-pulse, as long as the harmonic requirements of this Specification are met. Manufacturer may choose to provide higher pulse converters or harmonic filters as required to meet the current and voltage distortion limits.
2. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.
3. Basis for Harmonic Computations: Using Simplified Plant One-Line Diagram for current and voltage distortion computations, furnish harmonic filters, line reactors, isolation transformers, or higher pulse converter arrangements required to meet current/voltage distortion limits.
4. Standby Source Current Harmonic Distortion:
   a. Compute standby source individual and total current harmonic distortion at the incoming line terminals of motor control centers MCC-N1, MCC-N2, M, and switchgear SWGR-1, in accordance with IEEE Standard 519. Although the short circuit ratios indicated on the one line diagram for most of the PCC locations are higher than 20, the harmonic distortion limits specified below are deliberately specified for ration of less than 20, which will be the case in future. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current IL shall not exceed values specified in Table 2 below.

Table 2

Individual Harmonic Order (Odd Harmonics)	**Harmonic Current Distortion Percent of Max. Demand Load Current I_L**
h <11	1.0
11< = h<17	0.5
17< = h<23	0.375 (2.598 percent for h=17, 19)

Table 2	
Individual Harmonic Order (Odd Harmonics)	**Harmonic Current Distortion Percent of Max. Demand Load Current I_L**
23< = h<35	0.15
35< = h	0.075 (0.520 percent for h=35, 37
Total Demand Distortion (TDD)	5

b. Limits specified in Table 2 are for drives utilizing 18-pulse rectifiers.
c. For harmonics calculations, assume all drives running at full load.

5. Standby Source Voltage Harmonic Distortion: The individual voltage harmonic distortion computed at the incoming line terminals of motor control centers MCC-N1, MCC-N2, and switchgear SWGR-1, shall be less than 3 percent and the total harmonic voltage distortion shall not exceed 5 percent at all three PCC locations.
6. Furnish isolating transformers or series reactors, harmonic filters, or other devices necessary for proper system operation. Furnish necessary devices and circuits to prevent operation of one drive from adversely affecting operation of other drives supplied from same transformer or same bus.
7. When isolation transformers are used, design to meet K-factor requirements of drive(s) connected.
8. Furnish confirmation statement from the electrical Utility, that the plants Total Harmonic Distortion is within their requirements.

B. Design Requirements:

1. Design and provide drive system consisting of adjustable frequency controller, drive motor, certain auxiliary items, and components necessary for complete operating system.
2. Furnish AFDs rated on basis of actual motor full load nameplate current rating. (AFDs rating = 1.15* full load motor nameplant current.)
3. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using the pulse-width-modulation (PWM) technique to produce the adjustable frequency output.
4. System rated for continuous industrial duty and suitable for use with Standard NEMA MG 1, Design B motors.
5. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for the drive system.

6. Incoming Line Reactor: Design to minimize harmonic distortion on the incoming power feeder.
7. Output Reactor or dV/Dt Filter: Design to minimize voltage spikes at motor where long motor leads are indicated.
8. Bypass: Provide output isolation and bypass contactors with DRIVE/OFF/BYPASS selector switch as shown on Drawings.
9. Line Isolation Contractor: Provide line contactor to remove power from the AFD controller when in bypass mode as shown on Drawings.
10. The equipment furnished, including filters, transformed reactors, and contractors, must fit within the enclosures dimensions on the Drawings.

1.04 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.
2. Individual and total harmonic content (voltage and current) reflected in system normal source supply at driven equipment actual load at 70 and 100 percent of rated speed at the incoming line terminals of the motor control centers MCC-N1, MCC-N2, and switchgear SWGR-1. Show that the computed valves of individual and total current and voltage harmonic distortion are below the specified limits.
3. Individual and total current and voltage harmonic content reflected in STANDBY power source, at driven equipment actual load at 70 and 100 percent of rated speed at the incoming line terminals of the motor control centers MCC-N1, MCC-N2, and switchgear SWGR-1. Show that the computed values of individual and total current and voltage harmonic distortion are below the specified limits.
4. Individual and total current and voltage harmonic content reflected in STANDBY power source, at driven equipment actual load at 70 and 100 percent of rated speed at the incoming line terminals of the motor control centers MCC-N1, MCC-N2, and switchgear SWGR-1. Show that the computed values of individual and total current and voltage harmonic distortion are below the specified limits.
5. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer’s certification motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.
6. Data on shelf life of “dc link” capacitor.

7. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
8. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
9. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.
10. Maximum heat dissipation from enclosure.
11. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
12. Complete system operating description.
13. Complete system schematic (elementary) wiring diagrams.
14. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.
15. One-line diagram of system, including component ratings.
16. Description of diagnostic features being provided.
17. Descriptive literature for control devices such as relays and timers.
18. Itemized bill-of-materials listing system components.
19. Specific description of provisions, such as filters and harmonic suppression, being made to ensure proper system operation when system is supplied from standby engine generator specified in these Documents.
20. Provide information on interface with PLC.

B. Informational Submittals:

1. Statement of Supplier qualifications.
2. Factory functional test reports.
3. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE Standard 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.
4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer’s printed installation instructions.
6. Field test reports.
7. Manufacturer’s Certification of Proper Installation.
8. Suggested spare parts list to maintain equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.

9. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
10. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Supplier: Minimum 5 years' experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.

1.06 EXTRA MATERIALS

A. Furnish for each drive unit:

1. Complete set of components likely to fail in normal service.
2. Plug-in subassemblies.
3. Printed circuit boards.
4. Potentiometers.
5. Integrated circuits.
6. One complete power bridge and one spare printed circuit card for each modular, plug-in type card in controller.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Eaton Cutler Hammer.
2. Danfoss.
3. Siemens Robicon.
4. Allen-Bradley.
5. ABB.
6. Toshiba.
7. Square D.

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.03 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 degrees F to 104 degrees F.

B. Storage Temperature: Minus 40 degrees F to 158 degrees F.

C. Humidity: 0 percent to 95 percent relative (noncondensing).

D. Altitude: 0 to 3,300 feet.

E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

F. Atmosphere: Corrosive.

2.04 COMPONENTS

A. Drive Units:

1. Incorporate switching power supply operating from dc bus, to produce PWM output waveform simulating sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
2. Current-limiting semiconductor fuses for protection of internal power semiconductors.
3. Employ diode bridge rectifier providing constant displacement power factor of 0.95 minimum at all operating speeds and loads.
4. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
5. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50 volts dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for MTBF of 5 years.
6. Operate with open circuited output.
7. Input Voltage: 480V ac plus or minus 10 percent.
8. Output Voltage: 0 to 480 volts, three-phase, 0 to 66-Hz, minimum.
9. Maximum peak voltage of PWM AFD output pulse of 1,000 volts, with pulse rise time of not less than 2 microseconds, and a maximum rate of rise of 500 volts per microsecond. Maximum frequency of PWM AFD output pulse (carrier) frequency of 3,000-Hz. Should magnitudes of these characteristics be more stressful to motor insulation than specified values, furnish insulation systems on the motors suitable for the proposed values.
10. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than 3 dBA above that designated in NEMA MG 1 for same motor operated at constant speed with a 60-Hz supply voltage.
11. Short-Time Overload Capacity: 125 percent of rated load in rms current for 1 minute following full load, full speed operation.
12. Equipment Short-Circuit Rating: Suitable for connection to system with maximum source three-phase, bolted fault, short-circuit available of 65,000 amps rms symmetrical at 480 volts.
13. Furnish drives with output current-limiting reactors mounted within equipment enclosure.

14. Diagnostics: Comprehensive for drive adjustment and troubleshooting:
    a. Memory battery backup; 100-hour minimum during power loss.
    b. Status messages will not stop drive from running but will prevent it from starting.
    c. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
        1) Overcurrent (time and instantaneous).
        2) Overvoltage.
        3) Undervoltage (dc and ac).
        4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
        5) Serial communication fault.
        6) Short-circuit/ground fault (motor and drive).
        7) Motor stalled.
        8) Semiconductor fault.
        9) Microprocessor fault.
        10) Single-phase voltage condition.
15. Drive Protection:
    a. Fast-acting semiconductor fuses.
    b. Overcurrent, instantaneous overcurrent trip.
    c. Dc undervoltage protection, 70 percent dropout.
    d. Dc overvoltage protection, 130 percent pickup.
    e. Overtemperature, drive, inverter, converter, and dc link components.
    f. Overtemperature, motor, and pump.
    g. Single-phase protection.
    h. Reset overcurrent protection (manual or automatic reset).
    i. Active current limit/torque limit protection.
    j. Semiconductor fault protection.
    k. Short-circuit/ground fault protection.
    l. Serial communication fault protection.
    m. Microprocessor fault.
    n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
    o. Visual display of specific fault conditions.
16. Operational Features:
    a. Use manufacturer’s standard unless otherwise indicated.
    b. Sustained power loss.
    c. Momentary power loss.
    d. Power interruption.
    e. Power loss ride through (0.1 second).
    f. Start on the fly.
    g. Electronic motor overload protection.

h. Stall protection.
i. Slip compensation.
j. Automatic restart after power return (ability to enable/disable function).
k. Critical frequency lockout (three selectable points minimum, by 1.5-Hz steps in 10-Hz bands, to prevent resonance of system).
l. Drive maintenance system software for complete programming and diagnostics.
m. Ground fault protection, drive, and motor.
n. Operate with no motor connected to output terminals.

B. Rectifier: Three-phase 18-pulse (larger than 74 hp), 6-pulse (74 hp and less) full wave diode bridge rectifier to provide a constant dc voltage to the drive's dc bus.

C. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

D. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.

E. Enclosure:

1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
2. Furnish drive complete with cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator's controls. Components and controls specified in Section 26 05 04, Basic Electrical Materials and Methods.
3. Wire drive from below and above for power and control wiring.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.

5. Wiring:
    a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
    b. Label each terminal for permanent identification of leads.
    c. Identify each wire at each end with imprinted mylar adhesive-back wire markers.
    d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
    e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
    f. Wire connections internal to panels by crimp-on terminal types.
    g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
    h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.
6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

F. Operator Interface:

1. Controls: Mount drive local control on front door of enclosure and include control switch and membrane type keypad for the following operator functions:
    a. Start (when in local mode).
    b. Stop (when in local mode).
    c. Speed increase (when in local mode).
    d. Speed decrease (when in local mode).
    e. Parameter mode selection (recall programmed parameters).
    f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
    g. Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
    h. RUN/preset speed.
    i. Parameter lock, password or key switch lockout of changes to parameters.
    j. Start disable, key switch or programmed code.
2. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.
3. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).

4. Alphanumeric Display: During normal operation and routine test, the following parameters shall be available:
   a. Motor current (percent of drive rated current).
   b. Output frequency (Hertz).
   c. Output voltage.
   d. Running time.
   e. Local/remote indicator.
   f. Status of digital inputs and outputs.
   g. Analog input and output values.
   h. Output motor current per leg.
   i. All test points.
5. Adjustable Parameters: Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
   a. Frequency range, minimum, maximum.
   b. Adjustable acceleration/deceleration rate.
   c. Volts per Hertz (field weakening point).
   d. Active current limit/torque limit, 0 percent to 140 percent of drive rating.
   e. Adjustable voltage boost (IR compensation).
   f. Preset speed (adjustable, preset operating point).
   g. Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.
6. Control Diagrams: For control logic and interlock requirements, see applicable control diagrams shown on Contract Drawings.

G. Signal Interface:

1. Digital Input: High temperature contact closure input from field mounted motor temperature monitoring relay.
2. Communication Interface:
   a. All standalone drives shall interface with plant PLC.
   b. All motor control centers provided with 2 segment diagnostic repeater for interface with plant PLC system. All drives within motor control centers shall be shall communicate with PLC, refer to P&ID and Electrical drawings for additional connection requirements.
3. Coordinate data exchange from the drives and starters to the Plant Control System with PICS subcontractor.
   a. Data noted on Instrumentation and Control Legend Sheet 1, Drawing 001-G-118, shall be mapped into user map variables to optimize communications. The selection shall be made cooperatively with the PICA Supplier, see Section 40 90 00, Instrumentation and Control for Process Systems. Selection may be dictated by PICS functional requirement.

b. Data noted on motor control diagrams shall be mapped into user map variables to optimize communications.
c. Data to be mapped on each device is displayed on motor control diagrams.
    1) Data found in multiple motors shall be mapped to the same location in user map variables. For example, the motor running status shall appear in the same mapping location for all motors.
d. Provide PIC subcontractor with the network address of all device and mapping of data in the device at least two week prior to factory testing of the MCC. Mapping shall use tags used on motor control diagrams. For example, LSL for level switch low.

H. Provide output reactor or dV/Dt filter limit voltage spikes at the motor as recommended by manufacturer and/or as shown on the Drawings.

I. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

2.05 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
    a. Interior: One coat white enamel.
    b. Exterior: One coat manufacturer’s standard gray enamel or TIA/EIA 359-1, No. 61.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test one control panels identical to that furnished.

C. Record test data for report.

D. Functional Test: Perform manufacturer's standard.

1. Test diodes, transistors, and GTOs at a thermal level of 125 degrees C.
2. Test TTL and CMOS chips at 70 degrees C.
3. Test printed circuit boards while heat cycled to maximum temperature of 65 degrees C.
4. Test run power sections at maximum 40 degrees C for 12 hours and run with motors for 6 hours.
5. Test assembled drive at maximum 40 degrees C and full load, full speed for 4 hours.
6. Test power capacitors and active components.
7. Operate controller with motor throughout its specified range, and at rated power supply load for 1 hour.
8. Resonance: When harmonic filters are furnished to meet specified harmonic distortion requirements, perform analysis and furnish documentary evidence that filter elements do not resonate with remainder of system parameters at harmonic frequencies present.

E. Motor Test: See Section 26 20 00, Low Voltage AC Induction Motors.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
   a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
   b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 12-hour period without malfunction.
4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.
5. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion (up to and including 35th harmonic) at Incoming Line Terminals of Motor Control Centers MCC-N1, MCC-N2, and switchgear SWGR-1, under following load conditions:
      1) AFDs running at full load and half load.
      2) Half of the specified AFDs running at full load and half load.
   b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
   c. Individual and total voltage harmonic distortion at Incoming Line Terminals of Motor Control Centers MCC-N1, MCC-N2, and switchgear SWGR-1 under following conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
6. With plant load connected to standby power sources, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion (up to and including 35th harmonic) at Incoming Line Terminals of Motor Control Centers MCC-N1, MCC-N2, and switchgear SWGR-1, under following load conditions:
      1) AFDs running at full load and half load.
      2) Half of the specified AFDs running at full load and half load.
   b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
   c. Individual and total voltage harmonic distortion at Incoming Line Terminals of Motor Control Centers MCC-N1, MCC-N2, and switchgear SWGR-1 under following conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
7. Record test data for report.

C. Test Equipment:

1. Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

D. Field PLC Testing: Coordinate field PLC testing of each drive with the PICS Subcontractor. Testing of link between the plant control system and each standalone AFD shall be performed in three different stages as follows, and as specified in Section 40 90 00, Instrumentation and Control for Process Systems.

1. Pre-Functional Testing: Perform these tests on each drive. These tests are essentially repeats of the factory protocol tests except that the plant control PLC and the laptop is replaced with SCADA workstation HMI. Commands are issue from the workstation and response observed at the drive and at the work station graphic display. Verify the specified data exchange and document results.
2. Functional Testing: Repeat of Prefunctional testing with motors actually connected to the drives.
3. Performance Testing: As specified in Section 40 90 00, Instrumentation and Control for Process Systems.

3.03 MANUFACTURERS' SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

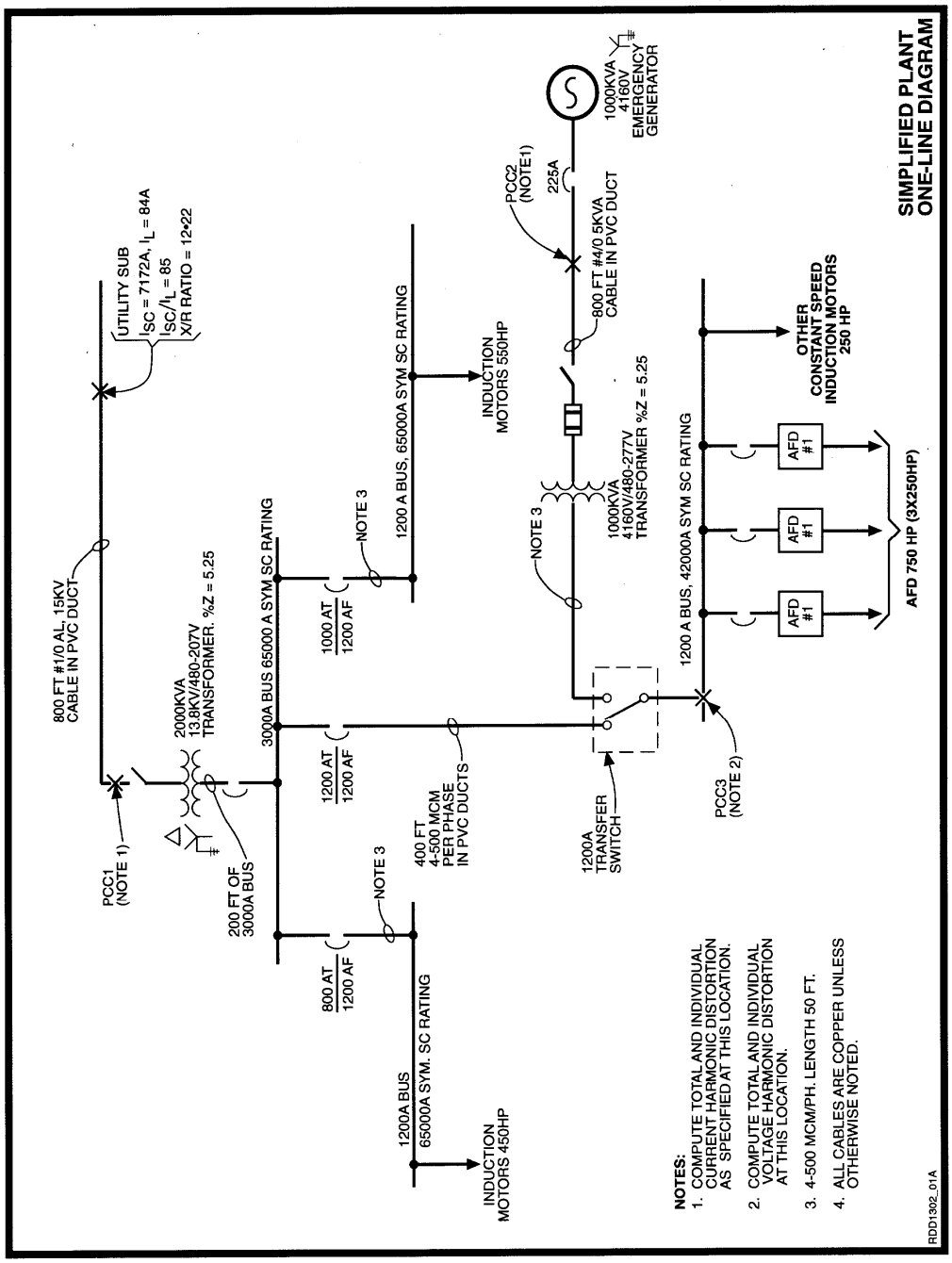
1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1/2 person-day for prestartup classroom or Site training.
4. 1/2 person-day for facility startup.
5. 1/2 person-day for post-startup training. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

3.04 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification.

1. Simplified Plant One-Line Diagram.

END OF SECTION



SECTION 26 32 13.13
DIESEL ENGINE GENERATOR SET

PART 1 GENERAL

1.01 WORK INCLUDED

A. Covers work necessary to furnish, install, connect, and test one complete factory assembled skid mounted diesel engine set. The engine generator set shall be complete and inclusive of an engine control panel, weather protected sound attenuated enclosure and double walled sub-base fuel tank.

B. See Section 26 23 00, Low Voltage Switchgear for interface requirements.

C. The Contractor shall be responsible for furnishing, installing, and testing the low voltage switchgear as specified in Section 26 23 00, Low-Voltage Switchgear, and for coordinating its operation with the engine generator set.

D. This section does not stand alone. Read this Section with Section 26 23 00, Low Voltage Switchgear. Coordinate all generator system control panel requirements with the low voltage switchgear control and protection schemes to provide a completely coordinated overall system.

1.02 SUBMITTALS

A. Action Submittals:

1. Dimensioned outline drawing showing plan and elevations of engine generator set and drive system, sub-base fuel tank, outdoor enclosure, and the fuel monitoring system including nozzle and vent arrangements and for the fuel tank.
2. Paragraph by paragraph specification compliance statement, describing differences between specified and proposed equipment.
3. Engine and generator weight, and anchoring requirements.
4. Catalog information and technical description; include materials for block, heads, valves, rings, cylinders, pistons, crankshaft, and major bearings and wear surfaces.
5. Complete list of accessories provided.
6. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rate, and kW output at design rated output, one-half load, and one-quarter load. Account for design altitude, temperature corrections, and engine parasitic loads.
7. Transient and subtransient reactances per unit.
8. Output waveform and telephone interference factor (TIF).

9. Circuit breaker data, including make model, catalog number, settings, and time current curves and enclosure size.
10. Cable termination lug data sheets.
11. Control panel instrument identification inscriptions.
12. Sample guarantee.
13. Electrical schematic and wiring diagrams for the following:
    a. Generator control panel.
    b. Main generator.
    c. Voltage regulator.
    d. Battery charging system.
    e. Governing system.
    f. Interconnection wiring diagram for automatic transfer specified in Section 26 14 13, Low-Voltage Switchgear.
    g. Enclosed electrical components.
14. Engine generator set motor starting capability and percent voltage dip curve.
15. Block heater size and voltage.
16. Heated fuel strainer system size and voltage.
17. Jacket water heater size and voltage.
18. Subbase tank size and dimensions.
19. Noise data for enclosed engine generator at 50 percent, 75 percent, and full load.
20. Exhaust system silencer pipe supports.
21. Recommended settings for the protective relaying functions of the engine-generator control panel
22. Anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Calculations for generator enclosure building, stairs, and access platform, including gravity and lateral force resisting system and anchors.
3. Generator set manufacturer qualifications.
4. Generator set UL 2200 certification documentation or independent certification.
5. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
6. Certified Factory Test Report.
7. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
8. Description of parts and service availability.

9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
10. Special guarantee.
11. Air quality permit.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Provide materials and equipment manufactured within the scope of standards published by UL in conformance with those standards documented with an applied UL listing mark.

B. Manufacturer Special Requirements:

1. Generator Set: Listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
2. Generator Set Manufacturer: Certified to ISO 9001 with third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.04 AIR QUALITY PERMIT

A. Obtain prior to releasing generator for production.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this Specification section found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

Item	Quantity
Diesel fuel line filter elements	3 complete sets
Lubricating oil filter elements with gasket	3 complete sets
Air cleaner filter element	1 complete set
Cooling fan drive belt (if applicable)	2 complete sets
Hydrometer	1 each
Two-pronged battery voltmeter	1 each
Spare fuses, if used in control panel	1 complete set
Spare indicating lamps (if applicable)	4 each type used
Touch up paint	1 quart each color used
Special tools required to maintain or dismantle engine generator set	1 complete se

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and equipment specified in this section shall be products of:

1. Kohler Power Series.
2. Cummins; Model.
3. Caterpillar; Model.

2.02 SERVICE CONDITIONS

A. Altitude: 800 feet above sea level.

B. Atmospheric Pressure: 14.7 psia

C. Ambient Temperature, Maximum: 110 degrees F.

D. Ambient Temperature, Minimum: 0 degree F.

E. Relative Humidity: 40 percent to 100 percent, high humidity.

F. The enclosures shall be designed to allow operation of the engine/generator within the environment specified above.

2.03 GENERAL

A. Ratings:

1. Operate at 1,800 rpm.
2. Rated at 1000 kW, 1250 kVA at 0.8 PF, based on specified service conditions.
3. Voltage: 480Y/277 volts, three-phase, four-wire, 60-Hz, wye connected alternator output.
4. Rated based on standby service.

B. Emissions:

1. Engines: Meet emission requirements specified in 40 CFR Chapter I Part 89 for stationary Internal Combustion (IC) engines.
2. Engine-generator set will be used strictly for standby emergency use

C. Vibration Design:

1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
2. Apply torsional analysis and design to mitigate torsional vibration.
3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

2.04 ENGINE

A. General:

1. Manufacturer’s standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.

B. Type:

1. Diesel Cycle, four-stroke type with unit mounted radiator and fan cooling.
2. Minimum Displacement: As recommended by generator manufacturer.
3. Minimum Number of Cylinders: Twelve.

C. Starting System:

1. Type: Automatic, using 24-volt battery-driven starter acting in response to control panel.
2. Starter: Capable of three complete cranking cycles without overheating.
3. Batteries:
   a. Sized as recommended by engine manufacturer. Battery shall be capable of supplying 24V dc power to the engine generator control panel and the generator system control panel located in the low voltage switchgear.
   b. Lead-acid type.
   c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
   d. Housed in acid-resistant frame isolated from engine generator main frame.
   e. Located such that maintenance and inspection of engine is not hindered.
   f. Complete with battery cables and connectors.
4. Battery Charger:
   a. UL 1236 listed and labeled.
   b. 20-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
   c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
   d. Located by generator manufacturer in generator control panel, or wall mounted in generator enclosure.
   e. Include:
      1) Ammeter and voltmeter.
      2) Fused ac input and dc output.
      3) Power ON pilot light.
      4) AC failure relay and light.
      5) Low and high dc voltage alarm relay and light.
   f. Alarm relay dry contacts rated 4 amps at 120V ac.
   g. Wire battery charger status and alarm contacts back to generator control panel, terminate and identify contacts. Interlock the alarm circuits with an adjustable time delay relay to avoid nuisance system alarms.
5. The engine shall be furnished with terminal blocks for connecting 24V dc power to the low voltage switchgear control power. Refer to Specification Section 26 23 00, low voltage switchgear for additional requirements.

D. Fuel System:

1. Engine driven, mechanical, positive displacement fuel pump.
2. Fuel filter with replaceable spin-on canister element.
3. Provide fuel cooler, suitable for operation of generator set at full rated load in ambient temperature specified if required for operation due to design of engine and installation.
4. Fuel strainer system.
5. As specified under Article Integral Subbase Fuel Tank.
6. Fuel Connections to Engine: Flexible hose, suitable for application.

E. Governing System:

1. Electronic type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Accessories:
   a. Manual speed control device.
   b. Positive overspeed trip switch.

F. Jacket Water Cooling System:

1. Radiator:
   a. Engine mounted.
   b. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
   c. Cooling System: Rated for full load operation in 122 degrees F (50 degrees C) ambient as measured at alternator air inlet.
   d. Fan: Suitable for use in a system with 0.5 in H_2O restriction.
   e. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
3. Jacket Water Heater:
   a. Suitable for operation on 208–volt, single-phase, 60-Hz current.
   b. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
   c. Thermostatically controlled.
4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

G. Lubrication System:

1. Type: Full-pressure.

2. Accessories:
    a. Pressure switch to initiate shutdown on low oil pressure.
    b. Oil filter with replaceable element.
    c. Bayonet type oil level stick.
    d. Valved oil drain extension.
3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket.

H. Exhaust System:

1. Muffler: Rated for critical grade silencing and coordinated with the noise limits specified for the generator enclosure; sized so as not to exceed allowable engine backpressure.
2. Pipe Connections: Welded.
3. Engine Connection:
    a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
    b. Length as required for flexibility and expansion in piping arrangement shown on Drawings.

I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.05 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. Stator Windings:
    a. Skewed for smooth voltage waveform.
    b. Reconnectable, 12 lead.
4. Overspeed Capability: 125 percent.
5. Waveform Deviation from Sine Wave: 5 percent maximum.
6. Telephone Interference Factor: 50 maximum.
7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

B. Insulation System:

1. Class H, with a maximum rise of 105 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
2. Vacuum pressure impregnated (VPI).

C. Excitation System:

1. Field brushless type or permanent magnet generator (PMG) exciter.
2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.

D. Voltage Regulation:

1. Solid state, three-phase sensing type.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.
4. Conformal coating environmental protection.

E. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
2. NEMA MG 1 Defined Transient Voltage Dip:
   a. Less than 20 percent at rapid application of rated load.
   b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

F. Motor Starting Capability:

1. Apply loads in the order listed in the following table. Stand by loads are not to be included in the following table:

Load Table

Step	Load Description	Rating	Type (Hp, Kw, Amps)	Starting Type	Largest Motor
1	50 % loads of MCC-N1+ 50 % loads of MCC-N2	See single line diagrams	See single line diagrams	See single line diagrams	75HP
2	50 % loads of MCC-N1+ 50 % loads of MCC-N2	See single line diagrams	See single line diagrams	See single line diagrams	75HP

G. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.

H. Main Circuit Breaker:

1. Type: Insulated case.
2. Current Rating: As recommended by generator manufacturer.
3. Interrupt Rating: 65,000 amps RMS symmetrical at 480 volts.
4. Short Time Rating: 35,000 amps RMS symmetrical.
5. Compression lugs for all feeder conductors including neutral and ground.
6. Trips:
   a. Solid state, RMS sensing.
   b. Adjustable Functions:
      1) Long-time current pickup.
      2) Long-time delay.
      3) High range instantaneous
      4) short-time pickup.
      5) Short-time delay with I2t function.
      6) Ground fault pickup.
      7) Ground fault delay.
7. Enclosure:
   a. Rating: NEMA 250, Type 12.
   b. Mounted with vibration isolation from engine generator set.
8. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.

I. Grounding Pads: Provide grounding terminals inside the alternator termination housing.

J. Noncorrosive stainless steel nameplate with not less than the minimum information called for in publication MG-1.

2.06 BASEPLATE

A. Mount engine generator set on a rigid common steel base frame.

B. Stiffen base frame to minimize deflections.

2.07 INTEGRAL SUBBASE FUEL TANK

A. General:

1. Full load operation of generator set for 48 hours.
2. UL 142 listed and labeled.
3. Installation: In compliance with NFPA 37.
4. Double-walled, steel construction including the following features:
   a. Emergency tank and basin vents.
   b. Mechanical level gauge.

c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
d. Fuel Fill Port: Locate external to the generator enclosure. Include a 7-gallon over-spill catch bucket and an over-spill prevention valve
e. Leak detection provisions, wired to generator set control for local and remote alarm indication.
f. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
g. Basin drain.
h. Integral lifting provisions.

2.08 VIBRATION ISOLATORS

A. Provide vibration isolators, spring/pad type.

B. Include seismic restraints if required by Site location.

2.09 FUNCTIONAL REQUIREMENTS-GENERATOR CONTROL SYSTEM

A. Local Manual Operation: when engine control switch on engine control panel is in MANUAL mode (with generator switchgear circuit breaker in the switchgear is OPEN), the engine will start and the generator will be brought to rated voltage and frequency. This mode of operation is used for no load testing of the generator. When the switch is OFF position, the engine cannot be started.

B. When engine control switch on engine control panel is in AUTOMATIC position, the engine START and STOP shall be controlled from the low voltage switchgear. Engine generator set shall start and run upon closure of a remote dry contact provided in Section 26 23 00, Low-Voltage Switchgear.

2.10 ENGINE CONTROL PANEL

A. Provide an engine mounted Engine Control Panel (ECP). This control panel shall include all indicators, control switches, alarms, and signal interfaces required for satisfactory operation of the engine generator set. The control panel shall receive signals from a variety of sensors on the engine and alternator including, but not limited to the following:

1. Temperatures: Coolant, after cooler, turbo inlet and exhaust, inlet air, engine oil.
2. Pressures: Atmospheric, turbo inlet/outlet, crank case, oil, fuel, etc.
3. Level: Coolant and fuel.

4. Speed sensors.
5. Alternator voltage/currents.

B. Control Panel:

1. Rating: NEMA 250, Type 12.
2. Material: Steel.
3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.
4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
6. Controls: Solid-state, microprocessor based. Control panel shall be designed and built by generator manufacturer to provide operating, monitoring, and control functions for generator set.

C. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
4. Fault Indication Lamps: Manufacturer’s standard.
5. Meters: Digital with analog display, plus or minus 2 percent accuracy.

D. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. Kilo-Watts (kW).
8. Percent kW.
9. Power Factor.
10. FREQUENCY meter.
11. Engine OIL PRESSURE indicator.
12. Engine jacket WATER TEMPERATURE indicator.
13. Engine SPEED indicator (RPM).
14. Engine OIL TEMPERATURE indicator.
15. RUNNING TIME indicator.
16. DC battery voltage.
17. Emergency Stop button.

E. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.
6. Control switch Not In Auto.
7. Battery charger Fail

F. External Interfaces:

1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
2. Output: Dry contact rated 5 amps at 120V ac.
3. Accept remote dry start contact closure from Low-Voltage Switchgear.

G. Functional Requirements:

1. LCD text display of alarm/event descriptions.
2. Recranking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recranking for a preset period of time after engine stop.
3. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
4. Cooldown timer, adjustable from 5 minutes to 60 minutes.
5. Alarms:
    a. Low coolant level.
    b. Low fuel level.
    c. Low battery voltage
    d. High battery voltage.
    e. Battery charger failure.
6. Engine shutdown upon any of the following conditions:
    a. Engine overspeed.
    b. Emergency stop button depressed.
    c. High jacket water temperature.
    d. Low oil pressure.
7. Air Inlet Damper Opening:
    a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
    b. Air Inlet Dampers: Fail open.

H. Special Requirements:

1. Mount battery charger generator enclosure.

2. The voltage regulator and related signal interfaces shall be preferably part of the ECP.
3. The governor control shall be included in the ECP.

I. Power Requirements: Manufacturers standard, internally connected to engine batteries or to load center in genset enclosure.

2.11 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. General:

1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.
2. Package shall comply with requirements of NEC for wiring materials and component spacing.
3. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
4. Housing:
   a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
   b. Doors:
      1) Hinged access doors as required to maintain easy access for operating and service functions.
      2) Lockable and include retainers to hold door open during service.
      3) Able to open 180 degrees without obstruction, except rear control panel door, which must open at least 135 degrees.
5. Roof: Cambered to prevent rainwater accumulation.
6. Openings: Screened to limit rodent access into enclosure.
7. Make electrical power and control interconnections within perimeter of enclosure.
8. Finishes:
   a. Prime sheet metal for corrosion protection and finish painted with manufacturer’s standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.
   b. Prime and paint surfaces of metal parts. Minimum coating requirements:
      1) Primer: 0.5 mil to 2.0 mils thick.
      2) Top Coat: 0.8 mil to 1.2 mils thick.
      3) Gloss:
         a) In accordance with ASTM D523, 80 percent plus or minus 5 percent.
         b) Gloss Retention After 1 Year: 50 percent minimum.

4) Crosshatch Adhesion: In accordance with ASTM D3359, 4B-5B.
5) Impact Resistance: In accordance with ASTM D2794, 120-inch to 160-inch pounds.
6) Salt Spray: In accordance with ASTM B117, plus 1,000 hours.
7) Humidity: In accordance with ASTM D2247, plus 1,000 hours.
8) Water Soak: In accordance with ASTM D2247, plus 1,000 hours.

c. Do not paint hoses, clamps, wiring harnesses, and other nonmetallic service parts.
d. Provide corrosion-resistant fasteners designed to minimize marring of painted surface when removed for normal installation or service work.

9. Enclosure Minimum Steel Thickness: 12-gauge for framework and 14-gauge for panels.
10. Hardware and Hinges: Austenitic stainless steel.
11. Exhaust Silencer:
    a. Install factory-mounted exhaust silencer inside enclosure.
    b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
    c. Provide seamless flexible exhaust connections to generator set.
12. Maintenance Provisions:
    a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
    b. External radiator-fill provision.
    c. External fuel fill provision (if equipped with a sub-based fuel tank).
13. Provide motorized louvers to minimize air flow through enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
14. Provide rain hoods for inlet ducts.
15. Provide external emergency stop switch that is protected from accidental actuation.
16. Provide factory mounted and wired electrical distribution panel to serve all the auxiliaries of the generator set and enclosure, including, but not limited to, jacket water heater, battery chargers, alternator space heater, and engine control panel. Provisions required include:
    a. A single 480-volt, 3-phase, 60A power feed.
    b. Fused Disconnect: 60A, 3-pole, NEMA 12. Fuse rating: 45A.
    c. Step-Down Transformer: 15KVA, 480V-208Y/120V; mounted on rubber isolator pads.
    d. Distribution Panelboard: 100A, 208/120V, 3-phase, 4-wire; copper bus; NEMA 12; 100A main breaker; all necessary branch

circuit breakers to feed enclosure lights, receptacles, engine block heaters, battery charger, and other accessories.

e. Two duplex GFI receptacles, one inside enclosure, and one weatherproof receptacle on outside of enclosure.

f. Two three-way switches controlling three ac lamps mounted in vapor tight and gasketed fixtures.

g. Factory-wired normal ac service from panelboard to engine coolant and alternator heaters, and battery charger.

17. Internal Wiring: All wiring within the enclosure shall be EMT. Connections at the generator set shall be flexible, and shall be factory provided prior to shipment to the installation site.
    a.

18. Sound Attenuation:
    a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
    b. Design, provide, and install enclosure to reduce sound level of generator set while operating at full rated load to a maximum of 78 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
    c. Insulate enclosure with nonhydroscopic materials.

2.12 PLATFORM

A. Features:

1. Cantilever supported off base with 10-gauge formed steel frame, toe plates, railing posts (pipes), rails, and grate assemblies coated with powder black.
2. Do not connect platform to subbase tank.
3. Laser cut structural materials to a tolerance of 1/16 inch, allowing no sharp edges.
4. Bolts: 5/16-inch diameter, minimum.
5. Design platform to provide access to generator enclosure service doors for maintenance and inspection and, at minimum, wrap around sides and back of generator.
6. Provide ship’s ladder to access platform.
7. Platform Height: No greater than 1.5 inches above bottom of generator base frame.
8. Walkway Tread: 1-inch vertical steel grating, black powder coated, on 1-3/16-inch centers, connected by horizontal steel rods on 4-inch centers. Cover cut grate edges with 14-gauge, black powder coated, 1/2-inch by 1/2-inch angled steel.
9. Handrails: Horizontal, 42 inches above walkway.

10. Steel Component Coating: Pressure wash clean with an iron phosphate solution and apply 3 mils of high gloss black powder baked paint.
11. Platform, Walkway, and Ladder: Meet requirements of OSHA 3124.
12. Manufacturer: Generator System Support, Inc.

2.13 FACTORY FINISHING

A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer's standard heat-resistant engine paint.

2.14 FACTORY TESTS

A. General: Conform to NFPA 110.

B. Steady Load Test: Conduct a steady load run for the durations listed below at each applied load rating:.

1. 50 percent applied load for 1 hour.
2. 75 percent applied load for 1 hour.
3. 100 percent applied load for 3 hours.
4. Record at 15-minute intervals the generator output voltage, frequency, load current, oil pressure, and engine coolant temperature. Complete test reports shall be made which shall show the engine fuel consumption and kW output. Test results to be reviewed and approved prior to shipment.

C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.

D. Harmonic Test: Conduct at full load conditions on the actual unit or one of the same model and size.

E. Record and Report:

1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
2. Transient response.
3. Load/speed stability.
4. Engine fuel consumption.
5. Power output.
6. Harmonic analysis.

F. Factory Tests shall also include:

1. Resistance of all windings (cold).
2. Insulation resistance of all windings.
3. High potential on all windings.

4. Open circuit saturation.
5. Voltage balance on windings.
6. Current balance on windings.
7. Voltage transient at rated kVA (voltage regulation, stability, and response).
8. Regulator range test (voltage adjust).
9. Phase sequence.
10. Mechanical balance (vibration).
11. Inherent voltage regulation.
12. Shaft currents with calculated summary of parallel operation.

G. Provide 4 weeks' notice to the Owner and Owner's Representative before any factory test is conducted to allow witnessing the tests.

PART 3 EXECUTION

3.01 INSTALLATION

A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.

B. Install in accordance with NECA 404.

C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

3.02 FIELD FINISHING

A. Touch up damaged coating with paint system compatible to existing.

3.03 FIELD TESTS

A. General:

1. Conform to NFPA 110.
2. Fuel provided by Contractor.
3. Top off fuel after testing.

B. Perform field relay coordination and calibration before conducting any tests.

C. Coordinate the tests with the Owner so as to minimize disruptions to Plant operations.

D. Initial Commissioning:

1. Calibrate the generator with a minimum 4-hours load bank (resistive and reactive) operation including at least 1 hour at 25, 50, 75, and

100 percent rated load. Provide connections for load bank equipment and cables that are furnished by manufacturer.

2. Verify that the engine generator meets the EPA Air Permit Limits and the Tier 2 emissions limits. Tests performed shall include measuring the actual emissions from each engine generator when operating at 100 percent load.
3. Manufacturer's representative shall make necessary adjustments.
4. Complete transfer/retransfer operational tests shall be performed proving synchronizing and automatic and manual transfer operations as specified in Section 26 23 00, Low Voltage Switchgear. All specified functional requirements shall be verified by actual tests, including load assumption and transfer back to utility.
5. Put the generator into service to provide standby power to switchgear in the event that there is a utility outage while the Electrical Upgrade project is under way.

E. Performance Test:

1. Following the transfer of all loads to new switchgear the generator shall be given operational tests under full Plant load.
2. Operate 2 hours minimum under Plant load.
3. Load the generator with building loads and Plant treatment systems.
4. Manufacturer's representative shall make necessary adjustments.
5. Demonstrate ability of engine generator set to carry specified loads.
6. Demonstrate engine generator set preliminary alarms and safety shutdowns.
7. Complete transfer/retransfer operational tests shall be performed proving synchronizing and automatic and manual transfer operations as specified in Section 26 23 00, Low Voltage Switchgear. All specified functional requirements shall be verified by actual tests, including load assumption and transfer back to utility.
8. Control system test must be jointly performed with the PICS Subcontractor. Show that data exchange between the generator PLCs and the plant control system is working satisfactorily and the graphics at the plant HMI dynamically and accurately display all data acquired from generator PLC.
9. Demonstrate ability of engine generator set to carry specified loads.
10. Demonstrate engine generator set safety shutdowns.

F. Test Report: Record and report the following:

1. Electric load on generator.
2. Fuel consumption.
3. Exhaust temperature.
4. Ambient air temperature.

5. Safety shutdown performance results.
6. Noise levels at 7 meters Property line.

G. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to Engineer and Owner.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 3 person-days for installation assistance and inspection.
2. 3 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 3 person-days for prestartup classroom or Site training.
4. 3 person-days for facility startup.
5. 1 person-days for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Lightning Protection Institute (LPI): 175, Standard of Practice.
2. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 780, Standard for the Installation of Lightning Protection Systems.
3. UL:
   a. 96, Standard for Lightning Protection Components.
   b. 96A, Standard for Installation Requirements for Lightning Protection Systems.

1.02 DESIGN REQUIREMENTS

A. Provide lightning protection system design for the following structures:

1. Site pole mounted lights.
2. Headworks.
3. Bioreactors.
4. Reaeration Blowers.
5. Clarifiers.
6. Bioreactor Basin.
7. Alum Facility.
8. Grit Removal Pump.
9. Effluent Filters.
10. UV Disinfection.
11. Chemical Feed and Storage.
12. Operations Building.
13. Electrical Building.
14. Diesel Engine Generator.
15. Diesel Fuel Storage Tank.

B. Coordinate the installation requirements of the Surge Protective Devices. Devices provided under Section 26 43 00, Surge Protective Devices.

C. Design lightning protection system to comply with applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

1.03 SUBMITTALS

A. Action Submittals:

1. Signed and Sealed Drawings by a Tennessee Profession Engineer (PE):
   a. Lightning protection system layout.
   b. Component locations.
   c. Detailed plans.
2. Down conductor.
3. Connecting conductor.
4. Bond strap.
5. Air terminals.
6. Fittings.
7. Connectors.
8. Ground rods.

B. Informational Submittals:

1. Field test report.
2. Ground Witness Certification-Form LPI-175A.
3. Post-Installation Certification-Form LPI-175B.
4. UL 96 Master Label “C” Certification.

1.04 QUALITY ASSURANCE

A. Designer: Lightning protection system design shall be prepared by and signed and sealed by a professional engineer registered (PE) in the State of Tennessee.

B. System components shall be the product of a manufacturer regularly engaged in the manufacturing of lightning protection components in accordance with UL 96.

C. Lightning protection system shall be installed under direct supervision of an LPI 175 Certified Master Installer.

D. Inspection of final installation and grounding connection shall be performed by an LPI-certified inspector.

E. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

F. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Thompson Lightning.
2. IPC Protection.
3. Erico Eritech Lightning Protection Systems.
4. VFC, Inc.

2.02 GENERAL

A. Complete system shall bear UL 96 Master Label C.

B. System Material: Aluminum, unless otherwise specified.

C. Material shall comply in weight, size, and composition for the class of structure to be protected as established by NFPA 780.

2.03 COMPONENTS

A. Air Terminal:

1. Material: Solid aluminum with tapered or blunt points as required for application.
2. Length: Sufficient to extend minimum 10 inches above object being protected.
3. UL 96 Label B applied to each terminal.

B. Conductors:

1. Lightning System Conductors: Bare medium hard-drawn stranded tin-plated copper, or stranded aluminum as required for the application.
2. Main Down Conductor: Smooth twist stranding.
3. Connecting Conductor: Concentric stranding.
4. Bonding Conductor: Flexible strap.
5. Main down and connecting conductors shall bear the UL 96 Label A, applied every 10 feet.
6. Grounding Conductors: Stranded bare copper.

C. Cable Fastener and Accessories: Capable of withstanding minimum pull of 100 pounds.

D. Fittings:

1. Heavy-duty.
2. Bolts, Screws, and Related Hardware: Stainless steel.

E. Ground Rods:

1. Material: Copper-clad.

F. Grounding Connections:

1. Welds: Exothermic process.
2. Fasteners: Bolted clamp type, corrosion-resistant copper alloy.
3. Hardware: Silicone bronze.

G. Cable Connections and Splicers:

1. Welds: Exothermic process.
2. Fasteners: Bolted clamp type, corrosion-resistant copper alloy.
3. Through-Roof Connectors: Straight or right angle with bronze and lead seal flashing washer.

H. Conduit: Schedule 40 PVC, as specified in Section 26 05 33, Raceway and Boxes.

PART 3 EXECUTION

3.01 GENERAL

A. Workmanship to comply with all applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

B. Aluminum materials shall be used where required to meet the galvanic corrosion requirements of UL 96A.

C. Provide pitchpockets or method compatible with roofing to waterproof roof penetrations.

D. Install system in inconspicuous manner so components blend with building aesthetics.

3.02 EXAMINATION

A. Verify conditions prior to installation. Actual conditions may require adjustments in air terminal and ground rod locations.

3.03 INSTALLATION

A. Air Terminals:

1. Supports: Brackets or braces.
2. Parapet Bracket Attachment: Lag or expansion bolts.
3. Secure base to roof surface with adhesive or pitch compatible with roofing bond.
4. Provide terminal flashing at roof penetrations.
5. Perimeter Terminals:
   a. Maximum Spacing: 20 feet.
   b. Maximum Distance From Outside Edge of Building: 2 feet.
6. Roof Ridge Terminals: Maximum spacing 20 feet.
7. Mid-Roof Terminals: Maximum spacing 50 feet.
8. Provide blunt point air terminals for applications exposed to personnel.

B. Conductors:

1. Conceal whenever practical.
2. Provide 1-inch PVC conduit in building walls or columns for main downleads and roof risers.
3. Support: Maximum spacing for exposed conductors.
   a. Vertical: 3 foot.
   b. Horizontal: 4 foot.
4. Maintain horizontal and vertical conductor courses free from dips or pockets.
5. Bends: Maximum 90 degrees, with minimum 8-inch radius.
6. Install air terminal conductors on the structural roof surface before roofing composition is applied.

C. Bonding:

1. Bond to Main Conductor System:
   a. Roof-mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.
   b. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.
2. Bond each steel column or major framing members to grounding system.

3. Bond each main down conductor to grounding system.

D. Grounding System:

1. Grounding Conductor:
   a. Completely encircle building structure.
   b. Bury minimum 1 foot below finished grade.
   c. Minimum 2 feet from foundation walls.
2. Interconnect ground rods by direct-buried copper cables.
3. Maximum Resistance: 5 ohms when connected to ground rods.
4. Connections:
   a. Install ground cables continuous between connections.
   b. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and nonaccessible connections.
   c. Provide bolted clamp type mechanical connectors for all exposed secondary connections.
   d. Use bolted offset parapet bases or through-roof concealed base assemblies for air terminal connections.
   e. Provide interconnections with electrical and telephone systems and all underground water metal pipes.
   f. Provide electric service arrestor ground wire to building water main.

3.04 FIELD QUALITY CONTROL

A. Field Testing:

1. Isolate lightning protection system from other ground conditions while performing tests.
2. Resistance: Test ground resistance of grounding system by the fall-of-potential method.
   a. Test Resistance to Ground: Maximum 5 ohms.
   b. Install additional ground rods as required to obtain maximum allowable resistance.
3. Test Report:
   a. Description of equipment tested.
   b. Description of test.
   c. Test results.
   d. Conclusions and recommendations.
   e. Appendix, including appropriate test forms.
   f. Identification of test equipment used.
   g. Signature of responsible test organization authority.

END OF SECTION

SECTION 26 43 00
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. Department of Defense: MIL-STD-220C, Test Method Standard – Method of Insertion Loss Measurement.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
   b. C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
   c. C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 497A, Standard for Secondary Protectors for Communications Circuits.
   b. 1283, Standard for Electromagnetic Interference Filters.
   c. 1449, Standard for Surge Protective Devices.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data on each suppressor type, indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.
2. Electrical single-line diagram showing location of each SPD.
3. Manufacturer’s UL certified test data and nameplate data for each surge protective device (SPD).

1.03 QUALITY ASSURANCE

A. UL Compliance and Labeling:

1. SPDs for Power and Signal Circuits: Comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units listed and labeled by UL.
2. SPDs for Telephone Circuit Protection: Comply with UL 497A.

B. ANSI Compliance: Use SPD devices in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Eaton, SPD Series.

B. General Electric, Tranquell.

C. Square D, Surelogic.

D. Advanced Protection Technologies, Inc.

E. CITEL, MDS Series.

2.02 GENERAL

A. Unless indicated otherwise, provide direct bus-connected and factory-installed SPDs inside distribution equipment.

B. SPD Operating Conditions: Capable of performing at ambient temperatures between minus 40 degrees C and 60 degrees C, at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.

C. Connect SPDs through a fused switch or circuit breaker as selected by manufacturer. Provide overcurrent protection to allow full surge handling capabilities and afford safety protection from thermal overloads and short circuits.

D. SPD Short Circuit Current Rating (SCCR): No less than the SCCR of distribution equipment.

E. Design SPD devices to protect all modes (L-L, L-N, L-G, N-G) of electrical system being used.

F. Power Filter: Include a high-frequency extended range power filter for each SPD complimentary listed to UL 1283 as an electromagnetic interference filter.

G. Provide SPDs with the following monitoring and diagnostics:

1. LED-type indication lights to show normal and failed status of each protected phase.
2. Surge event counter.
3. Form C dry contact which operates when unit fails.

H. Provide UL Type 2 SPDs.

I. EMI/RFI Noise Suppression: -50dB attenuation at 100 kHz, tested per MIL-STD 220C.

J. Voltage Protection Rating (VPR):

Voltage Rating	L-N	N-G	L-G	L-L
208Y/120	800	800	800	1200
480Y/277	1200	1200	1200	2000
240 Δ	--	--	1200	1200
480 Δ	--	--	2000	2000

2.03 SERVICE ENTRANCE AND DISTRIBUTION SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C.

B. Surge current capacity shall be not less than the following:

1. L-L Capacity: 200 kA.
2. L-N Capacity: 200 kA.
3. L-G Capacity: 120 kA.
4. N-G Capacity: 120 kA.

C. Maximum Continuous Operating Voltage (MCOV): Not less than 115 percent of nominal system voltage.

D. Nominal Discharge Current (I_N): 20kA.

2.04 PANELBOARD SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category B.

B. Surge current capacity shall be not less than the following:

1. L-L Capacity: 80 kA.
2. L-N Capacity: 80 kA.
3. L-G Capacity: 80 kA.
4. N-G Capacity: 80 kA.

C. Nominal Discharge Current: 20 kA.

D. Suppressor shall be in an enclosure that has the same NEMA rating as the panel it protects or the TVSS may be integral to a panelboard.

E. UL 1449 maximum clamp voltage shall not be more than:

System Voltage	Phase	L-L or L-N Clamp Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.05 ANNUNCIATION

A. Provide unit or separately mounted LED-type indication lights to show the normal and failed status of each module. Provide one normally open and one normally closed contacts which operate when the unit fails.

2.06 SURGE COUNTER

A. Provide each TVSS rated above 100 kA with a counter displaying the number of voltage transients that have occurred on the unit input. The counter shall be battery backed and retain the count through system power outages.

2.07 PAIRED CABLE DATA LINE INTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Use bi-polar 1,500-watt silicon avalanche diodes between the protected conductor and earth ground.

C. Provide units with a maximum single impulse current rating of 80 amperes (10 by 1,000 microsecond-waveform).

D. Breakdown voltage shall not exceed 36 volts.

2.08 PAIRED CABLE DATA LINE EXTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Suppressors shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally.

C. Suppressors shall meet or exceed the following criteria:

1. Maximum single impulse current rating of 10,000 amperes (8 by 20 microsecond-waveform).
2. Pulse Life Rating: 3,000 amperes (8 by 20 microsecond-waveform): 2,000 occurrences.
3. Maximum clamping voltage at 10,000 amperes (8 by 20 microsecond current waveform), shall not exceed the peak of the normal applied signal voltage by 200 percent.

PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Provide SPDs when indicated on Drawings or in the equipment specifications.

B. Provide factory-installed SPDs as integral components to new switchgear, switchboards, motor control centers, panelboards and transfer switches. Externally mounted SPDs are not acceptable for new distribution equipment.

C. Externally mounted SPDs are acceptable for SPDs added to existing equipment as described below.

D. Electronic Equipment Paired Cable Conductors: Install data line suppressors at the low voltage input and output of each piece of equipment, including telephone cable entrance.

1. Use secondary protectors on lines that do not exit the structure.
2. Use primary protectors on lines that exit and enter the structure.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install suppressors according to manufacturer's recommendations.

B. Install suppressors directly to the cabinet which houses the circuit to be protected so that the suppressor leads are straight and short, with conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.

C. Provide connecting wires as short as possible with gently twisted conductors, tied together, to prevent separation.

1. Maximum Length: 24 inches.

D. Field Installed Conductors: As specified for building wire, not smaller than 8 AWG and not larger than 4 AWG. Provide device leads not longer than the maximum length recommended by manufacturer, unless specifically reviewed and approved by manufacturer.

E. Provide dedicated disconnecting means for SPD devices installed at main service entrance location, switchgear, and motor control centers. Provide dedicated 30-60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for SPD devices. Provide circuit breakers with interrupting capacity equal to that specified for other breakers at that location.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A572/A572A, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   d. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100-mm] Thick.
   e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
   f. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   g. A1011/A1011M, 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.
   h. D6576, Standard Specification for Flexible Cellular Rubber Chemically Blown.
   i. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
2. American Wood Protection Association (AWPA): M6, Brands Used on Forest Products.
3. Certified Ballast Manufacturer (CBM).
4. Federal Communications Commission (FCC).
5. Illuminating Engineering Society of North America (IESNA).
   a. HB-9, Lighting Handbook.
   b. LM-79, IES Electrical and Photometric Measurements of Solid-State Lighting Products.
   c. LM-80, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources.
   d. RP (Recommended Practices) Series.
   e. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.

6. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
7. National Electrical Manufacturers Association (NEMA):
8. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. ICS 6, Industrial Control and Systems: Enclosures.
10. National Energy Policy Act.
11. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC) – Softbound Version.
12. Rural Utilities Service (RUS): 1728F-700, Specification for Wood Poles, Stubs and Anchor Logs.
13. Underwriters Laboratories, Inc. (UL):
    a. 773, UL Standard for Safety Plug-In Locking Type Photocontrols for Use with Area Lighting - Fourth Edition; Reprint with Revisions Through and Including March 08, 2002.
    b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
    c. 924, Emergency Lighting and Power Equipment.
    d. 1598, UL Standard for Safety Luminaires.
    e. 2108, UL Standard for Safety Low Voltage Lighting Systems - First Edition; Reprint with Revisions through and Including February 24, 2014.
    f. 8750, UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products - First Edition; Reprint with Revisions Through and Including April 1, 2015.
14. U.S. Environmental Protection Agency and U.S. Department of Energy: Energy Star.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. General:
        1) Provide catalog data sheets and pictures for all products listed below.
        2) Proposed Luminaire Substitutions (Interior and Exterior): Provide an electronic photometric file in standard '.ies' file format per the Illumination Engineering Society of North America (IESNA) for any proposed luminaire substitution not identified on the project Luminaire Schedule. Obtain file from the luminaire manufacturer or approved independent photometric testing laboratory. Include the proposed substitute luminaire with all options identified on the project Luminaire Schedule.

b. Interior Luminaires:
   1) Catalog data sheets with pictures.
   2) Luminaire material, finish, dimensions, and metal gauge.
   3) Lens material, pattern, and thickness.
   4) Candle power distribution curves in two or more planes.
   5) Candle power chart 0 degree to 90 degrees.
   6) Lumen output chart.
   7) Average maximum brightness data in foot lamberts.
   8) Coefficients of utilization for zonal cavity calculations.
   9) Mounting or suspension details.

c. Exterior Luminaires:
   1) Catalog data sheets with pictures. Luminaire material, finish, dimensions, and metal gauge.
   2) Lens material, pattern, and thickness. Filters.
   3) IESNA lighting classification (BUG rating).
   4) Isolux diagram.
   5) Lighting distribution data and lighting distribution classification type as defined in IESNA HB 9.
   6) Fastening details to wall, pendant, or pole.
   7) Ballast type, location, and method of fastening.
   8) For light poles, submit catalog sheet, wind loading, pole deflection with fixture attached, total weight, all accessories, complete dimensions, and finish.
   9) Brackets and supports.
   10) Pole foundations.

d. Lamps:
   1) Voltages.
   2) Watts.
   3) Correlated Color Temperature (CCT).
   4) Color Rendering Index (CRI).
   5) Published rated life (in hours). Provide number of hours per start and operating temperature for published rated life hours indicated.
   6) Published rated initial and mean lumens.
   7) Lumen maintenance curve.
   8) Lamp type (ANSI designation, dimensions, shape, and base).
   9) Copy of lamp order, including individual quantities, for Project.

e. Ballasts:
   1) Type.
   2) Wiring diagram.
   3) Ballast factor.
   4) Nominal watts and input watts.
   5) Input voltage and power factor.

6) Starting current, line current, and restrike current values.
7) Sound rating.
8) Temperature rating.
9) Efficiency ratings.
10) Low temperature characteristics.
11) Emergency Ballasts:
    a) Electrical ratings.
    b) Lamp type compatibility.
    c) Battery capacity.
12) Dimming Ballasts: Operating principle (0V to 10V, etc.), dimming range, manufacturer certification for operation with proposed dimmers.

f. LED Source Systems:
1) General:
    a) IESNA LM-80 test reports.
    b) IESNA TM-21 ratings.
    c) Operating temperature range. Data sheet (chart/graph) describing life as a function of temperature.
    d) Warranty: Light engine and driver.
    e) Rated life.
    f) Surge protection.
    g) Thermal control device, heat sink.
    h) Enclosure and wiring information.
    i) Operating voltage range.
2) Electronic Module/Light Engine:
    a) Correlated Color Temperature (CCT).
    b) Color Rendering Index (CRI).
3) Drivers:
    a) Input Current Total Harmonic Distortion.
    b) Power factor.
    c) Sound rating.

g. Time Switches:
1) Wiring diagram.
2) Contact ratings.
3) Functional features.
4) Programmable capabilities.
5) Enclosure type, dimensions.

h. Lighting Contactor:
1) Type (mechanically or electrically held).
2) Enclosure.
3) Contact ratings and configuration.
4) Coil operating voltage.

i. Photoelectric Switches (Photocells):
1) Voltage.
2) Power consumption.

3) Load capacity (watts).
4) Contact ratings and configuration.
5) Time delay.
6) Light operating level controls.
7) Enclosure type and dimensions.
8) Mounting type.
9) Temperature range.
10) Features and options.

j. Photo Sensors/Controls for Daylight Harvesting Control:
1) System description, overall functionality.
2) Each component.
3) Electrical ratings (voltage, amperage, watts).
4) Wiring diagrams.
5) Programming.
6) Testing.

k. Wall box dimmers.

l. Dimming systems.

m. Occupancy Sensors:
1) Type.
2) Switching capacity.
3) Coverage.
4) Time delay AUTO/OFF adjustment.

n. Low Voltage Remote Control Wiring System:
1) Type.
2) Switching capacity.
3) Voltage rating.
4) Wiring diagrams.

o. Outdoor Motion Sensors.

p. Emergency Shunt Relay.

q. High mast lighting.

r. Standby lighting panel.

s. Luminaire lowering device.

t. Landscape Lighting:
1) Luminaires.
2) Controls.
3) Transformers.
4) Wiring.

u. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s printed installation instructions.

3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Provide materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. in conformance with those standards and with an applied UL listing mark.

B. Standard Products:

1. Provide materials and equipment of manufacturers regularly engaged in the production of products specified in this section and that are of equal material, design, and workmanship.
2. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to Bid opening in similar applications under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
3. Material and Equipment Manufacturing Date: Do not use products manufactured more than 3 years prior to date of delivery to Site.

C. Preinstallation Meeting: Occupancy Sensors: Arrange preinstallation meeting with manufacturer's factory authorized representative at Owner's facility, to verify placement of sensors and installation criteria.

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on Drawings.

B. Provide luminaires and components tested, listed, and labeled by UL, or other approved testing agency.

C. Provide luminaires with Illumination Engineering Society of North America (IESNA) formatted photometric files, ".ies" format, certified by the luminaire manufacturer for use with lighting software.

D. Luminaire Labels:

1. External label per ANSI C136.15.
2. Internal label per ANSI C136.22.

E. Provide luminaires rated by the manufacturer to start and operate to their full lumen capacity for rated life of the luminaire at the minimum low and maximum high ambient temperatures as defined in the Contract Documents at their installation location.

F. Feed-through type, or separate junction box.

G. Wire Leads: Minimum 18 AWG.

H. Component Access: Accessible and replaceable without removing luminaire from ceiling.

I. Soffit Installations (Interior or Exterior Damp Locations):

1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.
2. Ballast: Removable, prewired.

J. Exterior Installations:

1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. Ballast: Removable, prewired.
3. When factory-installed photocells are provided, entire assembly shall have UL label.

K. Marine Environments:

1. UL Labeled: MARINE, OUTSIDE TYPE.
2. Housing: Copper-free, aluminum in accordance with UL 595.

L. Illuminated Exit Signs:

1. Body: As scheduled.
2. Face: Stencil.
    a. Letters:
        1) 6-inch high by 3/4-inch stroke.
        2) Color: Red.
3. Mounting: As indicated.
4. Directional Arrows: As indicated on Drawings.

M. Emergency Lighting:

1. Power Pack: Self-contained, 120/277-volt dual voltage transformer, inverter/charger, sealed nickel cadmium battery, and indicator switch in accordance with UL 924.
2. Lighted, push-to-test indicator.
3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
5. Capable of protecting against excess charging and discharging.
6. Emergency Self-Diagnostic System:
    a. Solid state device with LED display and audible alarm.
    b. Automatic and manual test unit.
    c. Test for malfunction of lamps, battery, and charger board.
    d. Manufacturer: Lithonia.

N. Hazardous Classified Areas:

1. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL 844.

2.02 LAMPS

A. LED

1. Type Efficiency: Energy.
2. Color: Minimum of 50,000 hours life at no less than 70 percent initial lumen rating. 4100k (minimum) or as shown on Lighting Fixture Schedule. Minimum of 80 CRI. Color variation shall not exceed a 3 step MacAdam ellipse.

B. Manufacturers:

1. General Electric Co.
2. Osram Sylvania.
3. Phillips Lighting Company.
4. Venture.
5. Cree.

2.03 BALLASTS

A. General:

1. Meet requirements for fixture light output, reliable starting, radio interference, total harmonic distortion, electromagnetic interference, and dielectric rating.
2. Certified by electrical testing laboratory to conform to CBM specifications.
3. Manufacturers:
   a. Osram Sylvania.
   b. Philips Advance.
   c. Universal Lighting Technologies.
   d. GE Lighting.
   e. Lutron.
   f. Holophane.

B. Fluorescent (Electromagnetic): Not allowed.

2.04 LED SOURCE SYSTEMS

A. LED (Driver):

1. Expected life: 100,000 hours.
2. Efficiency: High.
3. Power factor of 90 percent or greater (Class 1).
4. Total harmonic distortion THD shall be less than 20 percent.
5. Shall withstand line transients per IEEE C62.41, Cat C. Low, with intrigul surge protection device.
6. Shall not contain PCB’s and shall carry a minimum 3-year manufacturer’s warranty.
7. Ballast shall start lamp at a minimum temperature of 0 degree F.

2.05 LIGHTING CONTROL

A. Time Switch:

1. Provide digital electronic time switches with number of channels indicated on Drawings. Each channel shall be independently programmable and shall have a Form C dry contact, output rated for 10 amps at 120V ac. Time switches shall have, as a minimum, the following features:
   a. Selectable am/pm or 24-hour format.
   b. 1-minute time resolution.
   c. Programmable up to 48 events per channel.
   d. Weekly or 365-day capability.

e. Holiday capability.
f. User-programmable daylight savings time adjustment option.
g. Automatic leap year compensation.
h. Battery backup with rechargeable batteries and 72-hour capacity.
i. Individual manual ON/OFF override control for each channel.
j. Manufacturers:
1) Tork.
2) Paragon Electric Company.

B. Lighting Contactor:

1. Features:
a. Electrically held contactor.
b. Contacts Rating: 120 volts, 30 amperes, and 2 poles.
c. Enclosure: NEMA 1 conforming to NEMA ICS 6.

C. Photoelectric Switch (Photocell):

1. Automatic Solid State ON/OFF Switching Photo Control:
a. Dry Contacts:
1) Compatible with connected load device indicated on Drawings.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Mounting Type: 1/2-inch conduit entry.
4. Setting: ON at dusk and OFF at dawn.
5. Time delay feature to prevent false switching.
6. Field adjustable to control operating light levels.
7. Integral surge protection.
8. Manufacturers:
a. Tork.
b. Intermatic.
c. Paragon Electric Company.

D. Photo Sensors/Controls for Daylight Harvesting Control:

1. General.
a. Operating Temperature: 32 degrees F to 120 degrees F.
b. Environment: Indoor dry.
c. Illumination Sensing Levels:
1) 10 Foot-candles to 200 Foot-candles: General interior spaces.
2) 100 Foot-candles to 1,000 Foot-candles: Atriums, light shelves.

3) 1,000 Foot-candles to 10,000 Foot-candles: Light wells, skylights.

d. Output: Compatible with individual lighting load characteristics controlled.

2. Switching Control:
   a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and shall convey changes to a control unit/power pack switching device. Switching device shall open and close load contacts based on field programmable set points.
   b. Power Pack:
      1) Dry contacts rated 20A at 120/277V ac.
      2) Adjustable Time Delay: 5 seconds to 300 seconds.
      3) Set point adjustment for both on and off operation.
3. Dimming Control:
   a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and modulate electric luminaire lighting output to maintain a fixed lighting level in the space.
   b. Controller Unit:
      1) 120/277V ac input.
      2) 24V dc output to power the sensor.
   c. Sensor Output: 0V dc to 10V dc.
   d. Light level set point adjustment performed by separate hand held remote control device.

E. Low Voltage Remote Control Wiring System:

1. Provide a complete low-voltage, remote control wiring system for control of lighting fixtures as indicated on Drawings and Schedules. Provide complete system including transformers, rectifiers, relays, switches, master switches, electronic controls, enclosures, wall plates, and wiring of same manufacturer.
2. Remote Control Wiring: In accordance with Article 725, Class 2 of NFPA 70.
3. Provide for Direct-Wired Connection of:
   a. Standard of pilot light switches for individual control of relays.
   b. Two independent master override inputs which allow ON/OFF control of all relays while still supporting individual control of each relay.
4. Provide relay panels configured to allow future addition of up to two master controls of programmable control of all relays.

2.06 POLES

A. General:

1. Design for wind load as specified in Section 01 61 00, Common Product Requirements, while supporting luminaires and other appurtenances. Use effective projected areas (EPA) of luminaires and appurtenances in calculations specific to the actual products proposed on each pole. All exterior post/pole mounted light fixtures shall have a hand hole at the base, lightning protection in hand hole and ground conductor connected to ground rod at base. Hand hole shall provide easy access to light fixture fusing and lightning protection ground lug. Lightning protection ground lug shall be provided inside post/pole, electrically in contact with pole, for connection to ground rod. Provide and install ground wire from ground lug to ground rod, concealing ground wire through post/pole base. Anchor bolts to be galvanized.
2. Poles 30 feet and Shorter: One-piece construction.
3. Pole Height: As indicated on Luminaire Schedule.
4. Do not install scratched, stained, chipped, or dented poles.

B. Concrete Poles:

1. Cross-Sectional Shape: multi-sided.
2. Steel Reinforcing:
   a. Prestressed Concrete Pole Shafts: Reinforce with steel prestressing members.
   b. Design for internal longitudinal loading by either pretensioning or post-tensioning of longitudinal reinforcing members.
3. Tensioned Reinforcing:
   a. Primary Reinforcement Steel Used for a Prestressed Concrete Pole Shaft: Tension to between 60 percent and 70 percent of its ultimate strength.
   b. Design reinforcement so that when reinforcement is tensioned to 70 percent of its ultimate strength, the total resultant tensile force does not exceed the minimum section compressive strength of the concrete.
4. Coating and Sleeves for Reinforcing Members:
   a. Where minimum internal coverage cannot be maintained next to required core openings, such as handhole and wiring inlet, protect reinforcing with a vaporproof noncorrosive sleeve over the length without the 1/2-inch concrete coverage.
   b. Coat each steel reinforcing member to be post-tensioned with a nonmigrating slipper coating prior to the addition of concrete to ensure uniformity of stress throughout length of such member.

5. Strength Requirement:
    a. Naturally cured to achieve a 28-day compressive strength of 7,000 psi.
    b. Do not subject to severe temperature changes during curing period.
6. Shaft Preparation:
    a. Completed Prestressed Concrete Pole Shaft Surface:
        1) Hard, smooth, and nonporous.
        2) Resistant to soil acids, road salts, and attacks of water and frost.
        3) Clean, smooth, and free of surface voids and internal honeycombing.
    b. Install a minimum of 15 days after manufacture.

C. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.188-inch wall thickness.
2. Shape: Round.
3. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
4. Shaft Top: Fitted with cap.
5. Base:
    a. Anchor bolt mounted and machined to receive lower end of shaft.
    b. Welded joint between shaft and base.
    c. Base Cover: Cast aluminum alloy.
    d. Hardware, Except Anchor Bolts: either anodized aluminum alloy or stainless steel.
    e. Handhole.
6. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.
7. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.
8. Pole and Bracket Finish: Finish to match fixture.

2.07 BRACKETS AND SUPPORTS

A. Features:

1. Not less than 1-1/4-inch galvanized steel pipe secured to pole.
2. Slip-fitter or pipe-threaded brackets may be used, but coordinate brackets to luminaires provided. Provide identical brackets for use with one type of luminaire.

3. Select brackets for pole-mounted street lights to correctly position luminaire no lower than mounting height indicated.
4. Mount brackets not less than 24 feet above street.
5. Provide special mountings or brackets as indicated on Drawings fabricated of metal which will not promote galvanic reaction with luminaire head.

2.08 POLE FOUNDATIONS

A. Anchor Bolts: Steel rod having a minimum yield strength of 50,000 psi; at minimum, galvanize the top 12 inches of the rod.

B. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.09 EMERGENCY BALLAST

A. In accordance with UL 924.

B. Nickel cadmium battery, charger, and electronic circuitry in metal case.

C. Solid state charging indicator monitoring light and double-pole test switch.

D. Capable of operating lamps for a period of 90 minutes with output of 1,100 lumens to 1,200 lumens.

E. Manufacturers:

1. MagneTek Lighting Products.
2. Philips-Bodine.
3. Hubbell Lighting; Dual-Lite.
4. Lithonia.

2.10 IN-LINE FUSE HOLDER AND FUSE

A. Fuse Holder:

1. General: Waterproof, of corrosion-resistant material.
2. Rating: 600 volts.

B. Fuse:

1. General: Midget, dual element.
2. Rating: 5-amp, voltage as required by application.

C. Manufacturer: Methods Electronics Inc. Network, Buss Div.

2.11 EQUIPMENT IDENTIFICATION

A. Manufacturer's Nameplate: Provide each item of equipment with a nameplate bearing manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.

B. Provide clear markings located to be readily visible to service personnel.

2.12 FACTORY FINISH

A. Provide electrical equipment with factory-applied painting systems that, at minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:

1. Install in accordance with manufacturer's recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building required to safely mount.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:
   a. Coordinate mounting, fastening, and environmental conditions with Section 26 05 02, Basic Electrical Requirements.
   b. Refer to Fastener Schedule in Section 05 50 00, Metal Fabrications.
2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.
3. Pendant Mounted:
   a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
   b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
   c. Provide twin-stem hangers on single luminaires.
   d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.

C. Swinging Type: Provide, at each support, safety cable capable of supporting four times vertical load from structure to luminaire.

D. Finished Areas:

1. Install symmetrically with tile pattern.
2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
5. Junction Boxes:
   a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.
   b. In concealed locations, install junction boxes to be accessible by removing luminaire.
6. Wiring and Conduit:
   a. Provide wiring of temperature rating required by luminaire.
   b. Provide flexible steel conduit.
7. Provide plaster frames when required by ceiling construction.
8. Independent Supports:
   a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
   b. Select chain or wire with tensile strength and method of fastening to structure adequate to support luminaire weight.
   c. Fasten chain or wire to each end of luminaire.

E. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Fixture Suspension: Provide 3/8-inch threaded steel hanger rods. Scissor type hangers not permitted.
2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

F. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LAMPS

A. Provide in each fixture, number and type for which fixture is designed, unless otherwise noted.

3.03 BALLASTS

A. Install in accordance with manufacturer's recommendations.

B. Utilize all ballast mounting holes to fasten securely within luminaire.

C. Replace noisy or defective ballasts.

3.04 LIGHTING CONTROL

A. Outdoor Luminaires: Time clock with manual override switch lights ON at dusk and OFF at dawn.

B. Dimming Systems:

1. Install in accordance with manufacturer's recommendations.
2. Do not connect ballasts or equipment to dimming system unless acceptable to dimming system manufacturer.

C. Occupancy Sensors: Locate and aim sensors in correct location required for complete and proper volumetric coverage within range of coverage(s) of controlled areas per manufacturer's recommendations. Provide 90 percent to 100 percent room coverage to accommodate all occupancy habits of single or multiple occupants at any location within room(s). Locations and quantities of sensors shown on Drawings are diagrammatic and only indicate which rooms are to be provided with sensors. Provide additional sensors if required to properly and completely cover respective room.

3.05 EMERGENCY BALLAST

A. Install battery, charger, and electronic circuitry metal case inside fixture housing adjacent to ac ballast.

B. Install monitoring light and double-pole switch adjacent to light fixture.

C. Wire in accordance with manufacturer's wiring diagrams.

3.06 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

D. Provide separate circuit wiring to luminaire.

3.07 STANDBY LIGHTING UNIT

A. Install in accordance with manufacturer’s recommendations.

B. Provide separate circuit wiring to luminaire.

C. Provide permanent circuit connections with conduit and wire.

3.08 POLES

A. Electrical Installations: Conform to IEEE C2 and requirements specified herein.

B. Pole Setting:

1. Depth: As indicated on Drawings or footing detail.
2. Install poles in straight runs in a straight line.
3. Soil Setting: Depths shall apply where pole holes are in soil, sand, or gravel or any combination of these.
4. Setting on Sloping Ground: On sloping ground, measure depth of hole from low side of hole.
5. Backfill: Tamp pole backfill for the full depth of hole and mound excess fill around pole.
6. Dig holes large enough to permit the proper use of tampers to the full depth of the hole.
7. Place backfill in the hole in 6-inch maximum layers and thoroughly tamp.
8. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

C. Poles: Install according to pole manufacturer's instructions.

D. Photocell Switch Aiming: Mount and aim switch according to manufacturer's recommendations.

E. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.09 FIELD FINISHES

A. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Paint as specified in Section 09 90 00, Painting and Coating.

3.10 FIELD QUALITY CONTROL

A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

B. Coordinate lighting and controls installation and testing with commissioning as specified in Section 01 91 14, Equipment Testing and Facility Startup.

3.11 MANUFACTURER'S SERVICES

A. Occupancy Sensors:

1. Furnish manufacturer's representative at jobsite in accordance with Section 01 43 33, Manufacturers' Field Services, to inspect installation, test unit, and put into service.
2. Provide, at Owner's facility, training necessary to familiarize Owner's personnel with operation, use, adjustment, and problem solving diagnosis of occupancy sensing devices and systems.

3.12 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touchup painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

END OF SECTION