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09/30/2016

SECTION 01 60 00
PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Transportation, handling, storage and protection.
- B. Product option requirements.
- C. Substitution limitations and procedures.
- D. Maintenance materials, including extra materials, spare parts, tools, and software.

1.02 RELATED REQUIREMENTS

- A. Section 01 61 16 - Volatile Organic Compound (VOC) Content Restrictions: Requirements for VOC-restricted product categories.

1.03 SUBMITTALS

- A. Product Data Submittals: Submit manufacturer's standard published data. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this Project.
- B. Shop Drawing Submittals: Prepared specifically for this Project; indicate utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- C. Sample Submittals: Illustrate functional and aesthetic characteristics of the product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.
 - 1. For selection from standard finishes, submit samples of the full range of the manufacturer's standard colors, textures, and patterns.

PART 2 PRODUCTS

2.01 NEW PRODUCTS

- A. Provide new products unless specifically required or permitted by the Contract Documents.
- B. DO NOT USE products having any of the following characteristics:
 - 1. Made using or containing CFC's or HCFC's.
 - 2. Made of wood from newly cut old growth timber.
 - 3. Containing lead, cadmium, asbestos.
- C. Where all other criteria are met, Contractor shall give preference to products that:
 - 1. If used on interior, have lower emissions, as defined in Section 01 61 16.
 - 2. If wet-applied, have lower VOC content, as defined in Section 01 61 16.
 - 3. Have a published GreenScreen Chemical Hazard Analysis.

2.02 PRODUCT OPTIONS

- A. Products Specified by Reference Standards or by Description Only: Use any product meeting those standards or description.
- B. Products Specified by Naming One or More Manufacturers: Use a product of one of the manufacturers named and meeting specifications, no options or substitutions allowed.
- C. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions: Submit a request for substitution for any manufacturer not named.

2.03 MAINTENANCE MATERIALS

- A. Furnish extra materials, spare parts, tools, and software of types and in quantities specified in individual specification sections.
- B. Deliver to Project site; obtain receipt prior to final payment.

PART 3 EXECUTION

3.01 SUBSTITUTION PROCEDURES

- A. Document each request with complete data substantiating compliance of proposed substitution with Contract Documents.
- B. A request for substitution constitutes a representation that the submitter:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Agrees to provide the same warranty for the substitution as for the specified product.
 - 3. Agrees to coordinate installation and make changes to other Work that may be required for the Work to be complete with no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension that may subsequently become apparent.
 - 5. Agrees to reimburse Owner and Architect for review or redesign services associated with re-approval by authorities.

3.02 TRANSPORTATION AND HANDLING

- A. Package products for shipment in manner to prevent damage; for equipment, package to avoid loss of factory calibration.
- B. If special precautions are required, attach instructions prominently and legibly on outside of packaging.
- C. Coordinate schedule of product delivery to designated prepared areas in order to minimize site storage time and potential damage to stored materials.
- D. Transport and handle products in accordance with manufacturer's instructions.
- E. Transport materials in covered trucks to prevent contamination of product and littering of surrounding areas.
- F. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.
- G. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage, and to minimize handling.
- H. Arrange for the return of packing materials, such as wood pallets, where economically feasible.

3.03 STORAGE AND PROTECTION

- A. Designate receiving/storage areas for incoming products so that they are delivered according to installation schedule and placed convenient to work area in order to minimize waste due to excessive materials handling and misapplication.
- B. Store and protect products in accordance with manufacturers' instructions.
- C. Store with seals and labels intact and legible.
- D. Store sensitive products in weather tight, climate controlled, enclosures in an environment favorable to product.
- E. For exterior storage of fabricated products, place on sloped supports above ground.
- F. Protect products from damage or deterioration due to construction operations, weather, precipitation, humidity, temperature, sunlight and ultraviolet light, dirt, dust, and other contaminants.
- G. Comply with manufacturer's warranty conditions, if any.
- H. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to prevent condensation and degradation of products.
- I. Prevent contact with material that may cause corrosion, discoloration, or staining.
- J. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.

- K. Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

END OF SECTION

SECTION 01 61 16

VOLATILE ORGANIC COMPOUND (VOC) CONTENT RESTRICTIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Requirements for Indoor-Emissions-Restricted products.
- B. Requirements for VOC-Content-Restricted products.

1.02 DEFINITIONS

- A. Indoor-Emissions-Restricted Products: All products in the following product categories, whether specified or not:
 - 1. Interior paints and coatings.
 - 2. Interior adhesives and sealants, including flooring adhesives.
 - 3. Flooring.
 - 4. Products making up wall and ceiling assemblies.
 - 5. Thermal and acoustical insulation.
- B. VOC-Content-Restricted Products: All products in the following product categories, whether specified or not:
 - 1. Interior paints and coatings.
 - 2. Interior adhesives and sealants, including flooring adhesives.
- C. Interior of Building: Anywhere inside the exterior weather barrier.
- D. Adhesives: All gunnable, trowelable, liquid-applied, and aerosol adhesives, whether specified or not; including flooring adhesives, resilient base adhesives, and pipe jointing adhesives.
- E. Sealants: All gunnable, trowelable, and liquid-applied joint sealants and sealant primers, whether specified or not; including firestopping sealants and duct joint sealers.
- F. Inherently Non-Emitting Materials: Products composed wholly of minerals or metals, unless they include organic-based surface coatings, binders, or sealants; and specifically the following:
 - 1. Concrete.
 - 2. Clay brick.
 - 3. Metals that are plated, anodized, or powder-coated.
 - 4. Glass.
 - 5. Ceramics.
 - 6. Solid wood flooring that is unfinished and untreated.

1.03 REFERENCE STANDARDS

- A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; current edition.
- B. CARB (SCM) - Suggested Control Measure for Architectural Coatings; California Air Resources Board; 2007.
- C. SCAQMD 1113 - South Coast Air Quality Management District Rule No.1113; current edition; www.aqmd.gov.
- D. SCAQMD 1168 - South Coast Air Quality Management District Rule No.1168; current edition; www.aqmd.gov.

1.04 SUBMITTALS

- A. Product Data: For each VOC-restricted product used in the project, submit evidence of compliance.

PART 2 PRODUCTS

2.01 MATERIALS

- A. All Products: Comply with the most stringent of federal, State, and local requirements, or these specifications.

- B. Indoor-Emissions-Restricted Products: Comply with Indoor Emissions Standard and Test Method, except for:
 - 1. Inherently Non-Emitting Materials.
- C. VOC-Content-Restricted Products: VOC content not greater than required by the following:
 - 1. Adhesives, Including Flooring Adhesives: SCAQMD 1168 Rule.
 - 2. Joint Sealants: SCAQMD 1168 Rule.
 - 3. Paints and Coatings: Each color; most stringent of the following:
 - a. 40 CFR 59, Subpart D.
 - b. SCAQMD 1113 Rule.
 - c. CARB (SCM).

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

- A. Owner reserves the right to reject non-compliant products, whether installed or not, and require their removal and replacement with compliant products at no extra cost to Owner.
- B. Additional costs to restore indoor air quality due to installation of non-compliant products will be borne by Contractor.

END OF SECTION

SECTION 02 41 00
DEMOLITION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Selective demolition of built site elements.
- B. Selective demolition of building elements for alteration purposes.

1.02 RELATED REQUIREMENTS

- A. Section 00 31 00 - Available Project Information: Existing building survey conducted by Owner; information about known hazardous materials.
- B. Section 01 10 00 - Summary: Limitations on Contractor's use of site and premises.
- C. Section 01 10 00 - Summary: Sequencing and staging requirements.
- D. Section 01 10 00 - Summary: Description of items to be salvaged or removed for re-use by Contractor.
- E. Section 01 50 00 - Temporary Facilities and Controls: Site fences, security, protective barriers, and waste removal.
- F. Section 01 70 00 - Execution and Closeout Requirements: Project conditions; protection of bench marks, survey control points, and existing construction to remain; reinstallation of removed products; temporary bracing and shoring.
- G. Section 01 74 19 - Construction Waste Management and Disposal: Limitations on disposal of removed materials; requirements for recycling.

1.03 REFERENCE STANDARDS

- A. 29 CFR 1926 - U.S. Occupational Safety and Health Standards; current edition.
- B. NFPA 241 - Standard for Safeguarding Construction, Alteration, and Demolition Operations; 2013.

1.04 QUALITY ASSURANCE

- A. Demolition Firm Qualifications: Company specializing in the type of work required.

PART 3 EXECUTION

2.01 GENERAL PROCEDURES AND PROJECT CONDITIONS

- A. Comply with applicable codes and regulations for demolition operations and safety of adjacent structures and the public.
 - 1. Obtain required permits.
 - 2. Take precautions to prevent catastrophic or uncontrolled collapse of structures to be removed; do not allow worker or public access within range of potential collapse of unstable structures.
 - 3. Provide, erect, and maintain temporary barriers and security devices.
 - 4. Conduct operations to minimize effects on and interference with adjacent structures and occupants.
 - 5. Conduct operations to minimize obstruction of public and private entrances and exits; do not obstruct required exits at any time; protect persons using entrances and exits from removal operations.
- B. Do not begin removal until receipt of notification to proceed from Owner.
- C. Protect existing structures and other elements that are not to be removed.
 - 1. Provide bracing and shoring.
 - 2. Prevent movement or settlement of adjacent structures.
 - 3. Stop work immediately if adjacent structures appear to be in danger.

- D. If hazardous materials are discovered during removal operations, stop work and notify Architect and Owner; hazardous materials include regulated asbestos containing materials, lead, PCB's, and mercury.
- E. Perform demolition in a manner that maximizes salvage and recycling of materials.
 - 1. Dismantle existing construction and separate materials.
 - 2. Set aside reusable, recyclable, and salvageable materials; store and deliver to collection point or point of reuse.

2.02 SELECTIVE DEMOLITION FOR ALTERATIONS

- A. Drawings showing existing construction and utilities are based on casual field observation and existing record documents only.
 - 1. Verify that construction and utility arrangements are as shown.
 - 2. Report discrepancies to Architect before disturbing existing installation.
 - 3. Beginning of demolition work constitutes acceptance of existing conditions that would be apparent upon examination prior to starting demolition.
- B. Remove existing work as indicated and as required to accomplish new work.
 - 1. Remove items indicated on drawings.
- C. Services (Including but not limited to HVAC, Plumbing, Fire Protection, Electrical, Telecommunications, and _____): Remove existing systems and equipment as indicated.
 - 1. Maintain existing active systems that are to remain in operation; maintain access to equipment and operational components.
 - 2. Verify that abandoned services serve only abandoned facilities before removal.
 - 3. Remove abandoned pipe, ducts, conduits, and equipment, including those above accessible ceilings; remove back to source of supply where possible, otherwise cap stub and tag with identification.
- D. Protect existing work to remain.
 - 1. Prevent movement of structure; provide shoring and bracing if necessary.
 - 2. Perform cutting to accomplish removals neatly and as specified for cutting new work.
 - 3. Repair adjacent construction and finishes damaged during removal work.
 - 4. Patch as specified for patching new work.

2.03 DEBRIS AND WASTE REMOVAL

- A. Remove debris, junk, and trash from site.
- B. Leave site in clean condition, ready for subsequent work.
- C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION

SECTION 04 20 00
UNIT MASONRY

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Concrete Block.
- B. Mortar and Grout.
- C. Reinforcement and Anchorage.
- D. Lintels.

1.02 RELATED REQUIREMENTS

- A. Section 03 20 00 - Concrete Reinforcing: Reinforcing steel for grouted masonry.

1.03 REFERENCE STANDARDS

- A. ACI 530/530.1/ERTA - Building Code Requirements and Specification for Masonry Structures and Related Commentaries; American Concrete Institute International; 2011.
- B. ASTM C270 - Standard Specification for Mortar for Unit Masonry; 2014a.
- C. ASTM C387/C387M - Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar; 2011b.
- D. UL (FRD) - Fire Resistance Directory; Underwriters Laboratories Inc.; current edition.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for masonry units, fabricated wire reinforcement, mortar, and masonry accessories.
- C. Manufacturer's Certificate: Certify that masonry units meet or exceed specified requirements.

1.05 QUALITY ASSURANCE

- A. Fire Rated Assemblies: Conform to applicable code for UL Assembly No. ____.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, handle, and store masonry units by means that will prevent mechanical damage and contamination by other materials.

PART 2 PRODUCTS

2.01 CONCRETE MASONRY UNITS

- A. Concrete Block: Comply with referenced standards and as follows:
 - 1. Size: Standard units with nominal face dimensions of 16 x 8 inches (400 x 200 mm) and nominal depth of 8 inches (200 mm).

2.02 MORTAR AND GROUT MATERIALS

- A. Packaged Dry Material for Mortar for Unit Masonry: Premixed Portland cement, hydrated lime, and sand; complying with ASTM C387/C387M and capable of producing mortar of the specified strength in accordance with ASTM C270 with the addition of water only.
 - 1. Type: Type N.
 - 2. Color: Standard gray.

2.03 REINFORCEMENT AND ANCHORAGE

2.04 LINTELS

2.05 MORTAR AND GROUT MIXES

- A. Mortar for Unit Masonry: ASTM C270, using the Proportion Specification.

END OF SECTION

SECTION 05 51 00
METAL STAIRS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Prefabricated stairs.

1.02 REFERENCE STANDARDS

- A. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes; 2014.
- B. ASTM B221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes [Metric]; 2013.
- C. ASTM E935 - Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings; 2013.
- D. ASTM E985 - Standard Specification for Permanent Metal Railing Systems and Rails for Buildings; 2000 (Reapproved 2006).

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
 - 1. Include the design engineer's stamp or seal on each sheet of shop drawings.
- C. Delegated Design Data: As required by authorities having jurisdiction.

1.04 QUALITY ASSURANCE

- A. Fabricator Qualifications:
 - 1. A qualified steel fabricator that is certified by the American Institute for Steel Construction (AISC) under AISC 201.
- B. A qualified steel fabricator that is accredited by the International Accreditation Service (IAS) Fabricator Inspection Program for Structural Steel (AC172).
- C. A company specializing in manufacturing products specified in this section, with not less than ten years of documented experience.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Prefabricated Metal Stairs:
 - 1. Basis of Design: Erectastep: www.erecastep.com.
 - 2. fsIndustries: www.fsindustries.com.
 - 3. Wildeck: www.wildeck.com.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 METAL STAIRS - GENERAL

- A. Metal Stairs: Provide stairs of the design specified, complete with landing platforms, vertical and horizontal supports, railings, and guards, fabricated accurately for anchorage to each other and to building structure.
 - 1. Regulatory Requirements: Provide stairs and railings complying with the most stringent requirements of local, state, and federal regulations; where requirements of the contract documents exceed those of regulations, comply with the contract documents.
 - 2. Handrails: Comply with applicable accessibility requirements of ADA Standards.
 - 3. Dimensions: As indicated on drawings.
 - 4. Shop assemble components; disassemble into largest practical sections suitable for transport and access to site.
 - 5. No sharp or rough areas on exposed travel surfaces and surfaces accessible to touch.

6. Separate dissimilar metals using paint or permanent tape.
- B. Metal Jointing and Finish Quality Levels:
- C. Fasteners: Same material or compatible with materials being fastened; type consistent with design and specified quality level.
- D. Anchors and Related Components: Same material and finish as item to be anchored, except where specifically indicated otherwise; provide all anchors and fasteners required.

2.03 MATERIALS

- A. Stairways
 1. Stair treads and stringers shall be designed for a uniform live load of 100 pounds per square foot and a concentrated vertical load of 300 pounds distributed uniformly over an area of 4 square inches.
 2. Stair treads, stringers and risers shall be constructed using 6000 series aluminum alloy with 6061-T6 for primary structural components.
 3. All treads shall have ADA compliant nosing.
- B. Landings
 1. Landings shall be designed for a uniform live load of 100 pounds per square foot and a concentrated vertical load of 300 pounds distributed uniformly over an area of 1 square foot.
 2. Landings shall be constructed using 6000 series aluminum alloy with 6061-T6 for primary structural components.
- C. Legs
 1. The legs shall be designed to support the stair and landing sections.
 2. Legs shall be constructed using 6061-T6 aluminum alloy.
 3. All bolt hardware shall be stainless steel grade 304.
 4. All legs shall have 1/4"x6"x10" pads.
- D. Guard Rails
 1. Guardrail system shall be aluminum construction alloy 6061-T6 & 6063-T5.
 2. Guardrail systems shall be designed to resist a 200 pound concentrated horizontal load applied evenly over a one foot square area at any point in the system.
 3. Landing rails shall form a 42" high protective barrier such that a 4" sphere cannot pass through any opening in the landing rail.
- E. Hand Rails
 1. Handrails shall be aluminum construction alloy 6061-T6 & 6063-T5.
 2. Handrails shall be designed to resist a concentrated load of 200 pounds applied at any point and in any direction at the top of the rail.
 3. Handrails shall be designed to resist simultaneous load 50 pounds per linear foot applied horizontally and 100 pounds per linear foot applied vertically downward at the top of the rail.
 - a. Stair rail gripping surface shall be smooth and continuous.
 - b. Stair hand rail shall be 34" high from the nose of the tread to top of the rail measured perpendicularly from the tread nose.
 - c. Stair top rail shall be 1 1/4" Sch. 40 aluminum pipe with a barrier system of 4 inch spaced vertical pickets.
- F. Finishing
 1. All finishes shall be a mill finish.

2.04 ACCESSORIES

- A. Factory Fabricated Stair Tread and Nosing:
 1. Materials: Extruded aluminum type 6063-T5, mill finish.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field conditions are acceptable and are ready to receive work.

3.02 INSTALLATION

- A. Install per manufacturer's recommendations.
- B. Secure to existing concrete slab.

END OF SECTION

SECTION 06 10 00
ROUGH CARPENTRY

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Fire retardant treated wood materials.
- B. Miscellaneous framing and sheathing.
- C. Communications and electrical room mounting boards.
- D. Concealed wood blocking, nailers, and supports.
- E. Miscellaneous wood nailers, furring, and grounds.

1.02 REFERENCE STANDARDS

- A. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2009.
- B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2015a.
- C. AWPA U1 - Use Category System: User Specification for Treated Wood; American Wood Protection Association; 2012.
- D. PS 1 - Structural Plywood; 2009.
- E. PS 20 - American Softwood Lumber Standard; National Institute of Standards and Technology, Department of Commerce; 2010.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Dimension Lumber: Comply with PS 20 and requirements of specified grading agencies.
 - 1. If no species is specified, provide any species graded by the agency specified; if no grading agency is specified, provide lumber graded by any grading agency meeting the specified requirements.
 - 2. Grading Agency: Any grading agency whose rules are approved by the Board of Review, American Lumber Standard Committee (www.alsc.org) and who provides grading service for the species and grade specified; provide lumber stamped with grade mark unless otherwise indicated.
- B. Lumber fabricated from old growth timber is not permitted.

2.02 DIMENSION LUMBER FOR CONCEALED APPLICATIONS

- A. Sizes: Nominal sizes as indicated on drawings, S4S.
- B. Moisture Content: S-dry or MC19.
- C. Miscellaneous Framing, Blocking, Nailers, Grounds, and Furring:
 - 1. Lumber: S4S, No. 2 or Standard Grade.
 - 2. Boards: Standard or No. 3.

2.03 CONSTRUCTION PANELS

- A. Communications and Electrical Room Mounting Boards: PS 1 A-D plywood, or medium density fiberboard; 3/4 inch (19 mm) thick; flame spread index of 25 or less, smoke developed index of 450 or less, when tested in accordance with ASTM E84.

2.04 ACCESSORIES

- A. Fasteners and Anchors:
 - 1. Metal and Finish: Hot-dipped galvanized steel per ASTM A 153/A 153M for high humidity and preservative-treated wood locations, unfinished steel elsewhere.

2.05 FACTORY WOOD TREATMENT

- A. Treated Lumber and Plywood: Comply with requirements of AWPA U1 - Use Category System for wood treatments determined by use categories, expected service conditions, and specific applications.
 - 1. Fire-Retardant Treated Wood: Mark each piece of wood with producer's stamp indicating compliance with specified requirements.
- B. Fire Retardant Treatment:
 - 1. Interior Type A: AWPA U1, Use Category UCFA, Commodity Specification H, low temperature (low hygroscopic) type, chemically treated and pressure impregnated; capable of providing a maximum flame spread index of 25 when tested in accordance with ASTM E84, with no evidence of significant combustion when test is extended for an additional 20 minutes.
 - a. Kiln dry wood after treatment to a maximum moisture content of 19 percent for lumber and 15 percent for plywood.
 - b. Treat rough carpentry items as indicated .
 - c. Do not use treated wood in applications exposed to weather or where the wood may become wet.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

- A. Select material sizes to minimize waste.
- B. Reuse scrap to the greatest extent possible; clearly separate scrap for use on site as accessory components, including: shims, bracing, and blocking.
- C. Where treated wood is used on interior, provide temporary ventilation during and immediately after installation sufficient to remove indoor air contaminants.

3.02 BLOCKING, NAILERS, AND SUPPORTS

- A. Provide framing and blocking members as indicated or as required to support finishes, fixtures, specialty items, and trim.
- B. In framed assemblies that have concealed spaces, provide solid wood fireblocking as required by applicable local code, to close concealed draft openings between floors and between top story and roof/attic space; other material acceptable to code authorities may be used in lieu of solid wood blocking.
- C. In metal stud walls, provide continuous blocking around door and window openings for anchorage of frames, securely attached to stud framing.
- D. In walls, provide blocking attached to studs as backing and support for wall-mounted items, unless item can be securely fastened to two or more studs or other method of support is explicitly indicated.
- E. Where ceiling-mounting is indicated, provide blocking and supplementary supports above ceiling, unless other method of support is explicitly indicated.
- F. Provide the following specific non-structural framing and blocking:
 - 1. Grab bars.
 - 2. Towel and bath accessories.
 - 3. Wall-mounted door stops.

3.03 INSTALLATION OF CONSTRUCTION PANELS

- A. Communications and Electrical Room Mounting Boards: Secure with screws to studs with edges over firm bearing; space fasteners at maximum 24 inches (610 mm) on center on all edges and into studs in field of board.
 - 1. At fire-rated walls, install board over wall board indicated as part of the fire-rated assembly.
 - 2. Where boards are indicated as full floor-to-ceiling height, install with long edge of board parallel to studs.

3. Install adjacent boards without gaps.
4. Size and Location: As indicated on drawings.

3.04 TOLERANCES

- A. Framing Members: 1/4 inch (6 mm) from true position, maximum.
- B. Variation from Plane (Other than Floors): 1/4 inch in 10 feet (2 mm/m) maximum, and 1/4 inch in 30 feet (7 mm in 10 m) maximum.

3.05 CLEANING

- A. Waste Disposal: Comply with the requirements of Section 01 74 19 - Construction Waste Management and Disposal.
 1. Comply with applicable regulations.
 2. Do not burn scrap on project site.
 3. Do not burn scraps that have been pressure treated.
 4. Do not send materials treated with pentachlorophenol, CCA, or ACA to co-generation facilities or "waste-to-energy" facilities.
- B. Do not leave any wood, shavings, sawdust, etc. on the ground or buried in fill.
- C. Prevent sawdust and wood shavings from entering the storm drainage system.

END OF SECTION

SECTION 07 84 00
FIRESTOPPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Firestopping systems.

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

- A. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials; 2012.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2013a.
- C. ITS (DIR) - Directory of Listed Products; Intertek Testing Services NA, Inc.; current edition.
- D. FM 4991 - Approval Standard for Firestop Contractors; Factory Mutual Research Corporation; 2013.
- E. FM P7825 - Approval Guide; Factory Mutual Research Corporation; current edition.
- F. UL (FRD) - Fire Resistance Directory; Underwriters Laboratories Inc.; current edition.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on product characteristics, performance ratings, and limitations.

1.05 QUALITY ASSURANCE

- A. Fire Testing: Provide firestopping assemblies of designs that provide the scheduled fire ratings when tested in accordance with methods indicated.
 - 1. Listing in the current-year classification or certification books of UL, FM, or ITS (Warnock Hersey) will be considered as constituting an acceptable test report.
 - 2. Valid evaluation report published by ICC Evaluation Service, Inc. (ICC-ES) at www.icc-es.org will be considered as constituting an acceptable test report.
 - 3. Submission of actual test reports is required for assemblies for which none of the above substantiation exists.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Installer Qualifications: Company specializing in performing the work of this section and:
 - 1. Approved by Factory Mutual Research Corporation under FM 4991, or meeting any two of the following requirements:.
 - 2. With minimum 3 years experience installing work of this type.
 - 3. Able to show at least 5 satisfactorily completed projects of comparable size and type.

1.06 FIELD CONDITIONS

- A. Comply with firestopping manufacturer's recommendations for temperature and conditions during and after installation. Maintain minimum temperature before, during, and for 3 days after installation of materials.
- B. Provide ventilation in areas where solvent-cured materials are being installed.

PART 2 PRODUCTS

2.01 FIRESTOPPING - GENERAL REQUIREMENTS

- A. Primers, Sleeves, Forms, Insulation, Packing, Stuffing, and Accessories: Type required for tested assembly design.

2.02 FIRESTOPPING SYSTEMS

- A. Firestopping at Uninsulated Metallic Pipe and Conduit Penetrations, of diameter 4 inches (100 mm) or less: Caulk or putty.
 - 1. Floors: UL Design No. F-A-1046, F Rating 2 hour.
 - 2. 2-hour fire barriers and shaft walls: UL Design No. W-L-1146, F Rating 2 hour.
 - 3. 1-hour fire barriers and shaft walls: UL Design No. W-L-1146, F Rating 1 hour.
- B. Firestopping at Combustible Pipe and Conduit Penetrations, of diameter 4 inches (100 mm) or less: Intumescent elastomeric wrap strip with aluminum facing.
 - 1. Floors: UL Design No. F-A-2110, F Rating 2 hour.
 - 2. 2-hour fire barriers and shaft walls: UL Design No. W-L-2003, F Rating 2 hour.
 - 3. 1-hour fire barriers and shaft walls: UL Design No. W-L-2003, F Rating 1 hour.
- C. Firestopping at Openings with No Penetrating Items: Pillows with caulk or putty.
 - 1. 2-hour fire barriers and shaft walls: UL Design No. W-L-0011, F Rating 2 hour.
 - 2. 2-hour fire barriers and shaft walls: UL Design No. W-L-0011, F Rating 1 hour.
- D. Firestopping at Cable Penetrations, not in Conduit or Cable Tray: Intumescent elastomeric wrap strip with aluminum facing and caulk or putty.
 - 1. 2-hour fire barriers and shaft walls: UL Design No. W-L-3030, F Rating 2 hour.
 - 2. 1-hour fire barriers and shaft walls: UL Design No. W-L-3030, F Rating 1 hour.
- E. Firestopping at Penetrations with Insulated Metallic Pipe: Intumescent elastomeric wrap strip with aluminum facing and caulk or putty.
 - 1. Floors: UL Design No. F-A-5029, F Rating 2 hour.
 - 2. 2-hour fire barriers and shaft walls: UL Design No. W-L-5001, F Rating 2 hour.
 - 3. 1-hour fire barriers and shaft walls: UL Design No. W-L-5001, F Rating 1 hour.
- F. Firestopping at Penetrations with Rectangular Steel Duct: Packing material with sealant or caulk.
 - 1. 2-hour fire barriers and shaft walls: UL Design No. W-L-5001, F Rating 2 hour.
 - 2. 1-hour fire barriers and shaft walls: UL Design No. W-L-5001, F Rating 1 hour.
- G. Firestopping Between Edge of Floor Slab and Curtain Wall (without Penetrations): Fiber firestopping with smoke seal coating; UL Design No. _____, T Rating 3/4 hour.
- H. Firestopping Between Top of Partition Wall and Floor Slab: Fiber firestopping with smoke seal coating; UL Design No. HWD-0020, Assembly Rating: 2 hour.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify openings are ready to receive the work of this section.

3.02 PREPARATION

- A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter that could adversely affect bond of firestopping material.
- B. Remove incompatible materials that could adversely affect bond.

3.03 INSTALLATION

- A. Install materials in manner described in fire test report and in accordance with manufacturer's instructions, completely closing openings.
- B. Do not cover installed firestopping until inspected by authority having jurisdiction.
- C. Install labeling required by code.

3.04 CLEANING

- A. Clean adjacent surfaces of firestopping materials.

3.05 PROTECTION

- A. Protect adjacent surfaces from damage by material installation.

END OF SECTION

SECTION 08 11 13
HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Fire-rated hollow metal doors and frames.

1.02 RELATED REQUIREMENTS

- A. Section 08 71 00 - Door Hardware.

1.03 ABBREVIATIONS AND ACRONYMS

- A. ANSI - American National Standards Institute.
- B. ASCE - American Society of Civil Engineers.
- C. HMMA - Hollow Metal Manufacturers Association.
- D. NAAMM - National Association of Architectural Metal Manufacturers.
- E. NFPA - National Fire Protection Association.
- F. UL - Underwriters Laboratories.

1.04 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design; 2010.
- B. ANSI/SDI A250.3 - Test Procedure and Acceptance Criteria for Factory Applied Finish Coatings for Steel Doors and Frames; 2007 (R2011).
- C. ANSI/SDI A250.4 - Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames and Frame Anchors; 2011.
- D. ANSI/SDI A250.8 - Specifications for Standard Steel Doors and Frames (SDI-100); 2014.
- E. ANSI/SDI A250.10 - Test Procedure and Acceptance Criteria for Prime Painted Steel Surfaces for Steel Doors and Frames; 2011.
- F. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2015.
- G. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength, Low Alloy, and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable; 2015.
- H. ASTM 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; 2014.
- I. ICC A117.1 - Accessible and Usable Buildings and Facilities; International Code Council; 2009 (ANSI).
- J. ITS (DIR) - Directory of Listed Products; Intertek Testing Services NA, Inc.; current edition.
- K. NAAMM HMMA 805 - Recommended Selection and Usage Guide for Hollow Metal Doors and Frames; 2012.
- L. NAAMM HMMA 840 - Guide Specifications for Installation and Storage of Hollow Metal Doors and Frames; 2007.
- M. NAAMM HMMA 850 - Fire-Protection and Smoke Control Rated Hollow Metal Door and Frame Products; 2014.
- N. NAAMM HMMA 860 - Guide Specifications for Hollow Metal Doors and Frames; 2013.
- O. NFPA 80 - Standard for Fire Doors and Other Opening Protectives; 2013.
- P. NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives; 2013
- Q. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies; 2012.

- R. UL (BMD) - Building Materials Directory; current edition.
- S. UL 10C - Standard for Positive Pressure Fire Tests of Door Assemblies; Current Edition, Including All Revisions.
- T. UL 1784 - Standard for Air Leakage Tests of Door Assemblies; Current Edition, Including All Revisions.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Materials and details of design and construction, hardware locations, reinforcement type and locations, anchorage and fastening methods, and finishes; and one copy of referenced standards/guidelines.
- C. Shop Drawings: Details of each opening, showing elevations, glazing, frame profiles, and any indicated finish requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with NAAMM HMMA 840 or ANSI/SDI A250.8 (SDI-100) in accordance with specified requirements.
- B. Protect with resilient packaging; avoid humidity build-up under coverings; prevent corrosion and adverse effects on factory applied painted finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Hollow Metal Doors and Frames:
 - 1. Ceco Door; _____, an Assa Abloy Group company: www.assaabloydss.com.
 - 2. De La Fontaine Inc; Hollow Metal Door Model _____: www.delafontaine.com.
 - 3. De La Fontaine Inc; Windstorm-Resistant Steel Door and Frame; door style _____: www.delafontaine.com.
 - 4. De La Fontaine Inc; Hollow Metal Frame _____ Profile: www.delafontaine.com.
 - 5. Republic Doors; _____: www.republicdoor.com.
 - 6. Steelcraft; _____, an Allegion brand: www.allegion.com/us.
 - 7. Technical Glass Products; SteelBuilt Window & Door Systems: www.tgpamerica.com.
 - 8. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 DESIGN CRITERIA

- A. Requirements for Hollow Metal Doors and Frames:
 - 1. Steel used for fabrication of doors and frames shall comply with one or more of the following requirements; Galvannealed steel conforming to ASTM A653/A653M, cold-rolled steel conforming to ASTM A1008/A1008M, or hot-rolled pickled and oiled (HRPO) steel conforming to ASTM A1011/A1011M, Commercial Steel (CS) Type B for each.
 - 2. Accessibility: Comply with ICC A117.1 and ADA Standards.
- B. Combined Requirements: If a particular door and frame unit is indicated to comply with more than one type of requirement, comply with the specified requirements for each type; for instance, an exterior door that is also indicated as being sound-rated must comply with the requirements specified for exterior doors and for sound-rated doors; where two requirements conflict, comply with the most stringent.

2.03 HOLLOW METAL DOORS

- A. Type _____, Fire-Rated Doors:
 - 1. Based on NAAMM HMMA Custom Guidelines: Comply with NAAMM HMMA 850 requirements for fire-rated doors.
 - a. Comply with guidelines of NAAMM HMMA 860 for Hollow Metal Doors and Frames.
 - b. Performance Level 1 - Light Duty, in accordance with NAAMM HMMA 805.
 - c. Physical Performance Level C, 250,000 cycles; in accordance with ANSI/SDI A250.4.

- d. Door Face Metal Thickness: 20 gage, 0.032 inch (0.8 mm), minimum.
2. Fire Rating: As indicated on Door Schedule, tested in accordance with UL 10C and NFPA 252 ("positive pressure fire tests").
3. Temperature-Rise Rating (TRR) Across Door Thickness: In accordance with local building code and authorities having jurisdiction (AHJ).
4. Provide units listed and labeled by UL (Underwriters Laboratories) - UL (BMD) or WH (Warnock Hersey) - ITS (DIR).
 - a. Attach fire rating label to each fire rated unit.
5. Smoke and Draft Control Doors (Indicated with letter "S" on Drawings and/or Door Schedule): Self-closing or automatic closing doors in accordance with NFPA 80 and NFPA 105, with fire-resistance-rated wall construction rated the same or greater than the fire-rated doors, and the following;
 - a. Maximum Air Leakage: 3.0 cfm/sq ft (0.02 cu m/sec/sq m) of door opening at 0.10 inch w.g. (24.9 Pa) pressure, when tested in accordance with UL 1784 at both ambient and elevated temperatures.
 - b. Gasketing: Provide gasketing or edge sealing as necessary to achieve leakage limit.
 - c. Label: Include the "S" label on fire-rating label of door.
6. Door Thickness: 1-3/4 inch (44.5 mm), nominal.

2.04 HOLLOW METAL FRAMES

- A. Comply with standards and/or custom guidelines as indicated for corresponding door in accordance with applicable door frame requirements.
- B. Door Frames, Fire-Rated: Knock-down type.
 1. Fire Rating: Same as door, labeled.
 2. Frame Metal Thickness: 18 gage, 0.042 inch (1.0 mm), minimum.
 3. Frame Finish: Factory finished.
- C. Provide mortar guard boxes for hardware cut-outs in frames to be installed in masonry or to be grouted.
- D. Frames in Masonry Walls: Size to suit masonry coursing with head member 4 inch high (102 mm high) to fill opening without cutting masonry units.

2.05 ACCESSORIES

- A. Grout for Frames: Portland cement grout with maximum 4 inch (102 mm) slump for hand troweling; thinner pumpable grout is prohibited.
- B. Silencers: Resilient rubber, fitted into drilled hole; 3 on strike side of single door, 3 on center mullion of pairs, and 2 on head of pairs without center mullions.
- C. Temporary Frame Spreaders: Provide for factory- or shop-assembled frames.

2.06 FINISHES

- A. Primer: Rust-inhibiting, complying with ANSI/SDI A250.10, door manufacturer's standard.
- B. Factory Finish: Complying with ANSI/SDI A250.3, manufacturer's standard coating.
- C. Bituminous Coating: Asphalt emulsion or other high-build, water-resistant, resilient coating.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that opening sizes and tolerances are acceptable.
- C. Verify that finished walls are in plane to ensure proper door alignment.

3.02 PREPARATION

- A. Coat inside of frames to be installed in masonry or to be grouted, with bituminous coating, prior to installation.

3.03 INSTALLATION

- A. Install doors and frames in accordance with manufacturer's instructions and related requirements of specified door and frame standards or custom guidelines indicated.
- B. Install fire rated units in accordance with NFPA 80.
- C. Coordinate frame anchor placement with wall construction.
- D. Grout frames in masonry construction, using hand trowel methods; brace frames so that pressure of grout before setting will not deform frames.
- E. Coordinate installation of hardware.
- F. Touch up damaged factory finishes.

3.04 TOLERANCES

- A. Maximum Diagonal Distortion: 1/16 in (1.5 mm) measured with straight edge, corner to corner.

3.05 ADJUSTING

- A. Adjust for smooth and balanced door movement.

END OF SECTION

SECTION 08 71 00
DOOR HARDWARE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hardware for wood, aluminum, hollow metal, and _____ doors.
- B. Hardware for fire-rated doors.
- C. Thresholds.
- D. Weatherstripping, seals and door gaskets.

1.02 RELATED REQUIREMENTS

- A. Section 08 11 13 - Hollow Metal Doors and Frames.
- B. Section 08 71 10 - Basis of Design Door Hardware - Hager.

1.03 REFERENCE STANDARDS

- A. BHMA A156.2 - American National Standard for Bored and Preamsembled Locks & Latches; Builders Hardware Manufacturers Association; 2011 (ANSI/BHMA A156.2).
- B. BHMA A156.3 - American National Standard for Exit Devices; Builders Hardware Manufacturers Association; 2014 (ANSI/BHMA A156.3).
- C. BHMA A156.4 - American National Standard for Door Controls - Closers; Builders Hardware Manufacturers Association, Inc.; 2013 (ANSI/BHMA A156.4).
- D. BHMA A156.8 - American National Standard for Door Controls - Overhead Stops and Holders; Builders Hardware Manufacturers Association, Inc.; 2010 (ANSI/BHMA A156.8).
- E. BHMA A156.21 - American National Standard for Thresholds; Builders Hardware Manufacturers Association; 2014 (ANSI/BHMA A156.21).
- F. BHMA A156.22 - American National Standard for Door Gasketing and Edge Seal Systems, Builders Hardware Manufacturers Association; 2012 (ANSI/BHMA A156.22).
- G. DHI (LOCS) - Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames; Door and Hardware Institute; 2004.
- H. NFPA 80 - Standard for Fire Doors and Other Opening Protectives; 2013.
- I. UL (BMD) - Building Materials Directory; Underwriters Laboratories Inc.; current edition.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate the manufacture, fabrication, and installation of products that door hardware will be installed upon.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's catalog literature for each type of hardware, marked to clearly show products to be furnished for this project.
- C. Hardware Schedule: Detailed listing of each item of hardware to be installed on each door. Use door numbering scheme as included in the Contract Documents. Identify electrically operated items and include power requirements.
- D. Manufacturer's Installation Instructions: Indicate special procedures, perimeter conditions requiring special attention.

1.06 QUALITY ASSURANCE

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Allegion Brands; Ives, LCN, Schlage, Steelcraft, or Von Duprin: www.allegion.com/us.

- B. Assa Abloy Brands; Corbin Russwin, Curries, McKinney, Norton, Sargent, or Yale: www.assaabloydss.com.
- C. Best Access Systems, division of Stanley Security Solutions: www.bestaccess.com.
- D. C. R. Laurence Co., Inc: www.crl-arch.com.
- E. DORMA USA, Inc: www.dorma.com.
- F. Hager Companies: www.hagerco.com.

2.02 DOOR HARDWARE - GENERAL

- A. Provide hardware specified or required to make doors fully functional, compliant with applicable codes, and secure to the extent indicated.
- B. Provide items of a single type of the same model by the same manufacturer.
- C. Provide products that comply with the following:
 - 1. Applicable provisions of federal, state, and local codes.
 - 2. Fire-Rated Doors: NFPA 80.
 - 3. Hardware on Fire-Rated Doors, Except Hinges: Listed and classified by UL as suitable for the purpose specified and indicated.
 - 4. Hardware for Smoke and Draft Control Doors (Indicated as "S" on Drawings): Provide hardware that enables door assembly to comply with air leakage requirements of the applicable code.

2.03 LOCKS AND LATCHES

- A. Locks: Provide a lock for every door, unless specifically indicated as not requiring locking.
 - 1. If no hardware set is indicated for a swinging door provide an office lockset.
 - 2. Trim: Provide lever handle or pull trim on outside of all locks unless specifically stated to have no outside trim.
 - 3. Lock Cylinders: Provide key access on outside of all locks unless specifically stated to have no locking or no outside trim.
- B. Lock Cylinders: Manufacturer's standard tumbler type, six-pin standard core.
 - 1. Provide cams and/or tailpieces as required for locking devices required.
- C. Keying: Grand master keyed.
- D. Latches: Provide a latch for every door that is not required to lock, unless specifically indicated "push/pull" or "not required to latch".

2.04 HINGES

- A. Hinges: Provide hinges on every swinging door.
 - 1. Provide five-knuckle full mortise butt hinges unless otherwise indicated.
 - 2. Provide ball-bearing hinges at all doors having closers.
 - 3. Provide hinges in the quantities indicated.
 - 4. Provide non-removable pins on exterior outswinging doors.
 - 5. Where electrified hardware is mounted in door leaf, provide power transfer hinges.

2.05 CYLINDRICAL LOCKSETS

- A. Locking Functions: As defined in BHMA A156.2, and as follows.
 - 1. Office: F81, key not required to lock, remains locked upon exit.
 - 2. Always-Locked: F86, key required to lock, may not be left unlocked.
 - 3. Exit Only: F89, may not be left unlocked.

2.06 EXIT DEVICES

- A. Locking Functions: Functions as defined in BHMA A156.3, and as follows:
 - 1. Entry/Exit, Always-Locked: Key outside retracts latchbolt but does not unlock lever, no latch holdback.

2.07 CLOSERS

- A. Closers: Complying with BHMA A156.4.
 - 1. Provide surface-mounted, door-mounted closers unless otherwise indicated.
 - 2. Provide a door closer on every exterior door.
 - 3. Provide a door closer on every fire- and smoke-rated door. Spring hinges are not an acceptable self-closing device unless specifically so indicated.
 - 4. On pairs of swinging doors, if an overlapping astragal is present, provide coordinator to ensure the leaves close in proper order.
 - 5. At corridors, locate door-mounted closer on room side of door.
 - 6. At outswinging exterior doors, mount closer in inside of door.

2.08 STOPS AND HOLDERS

- A. Stops: Complying with BHMA A156.8; provide a stop for every swinging door, unless otherwise indicated.
 - 1. Provide wall stops, unless otherwise indicated.
 - 2. If wall stops are not practical, due to configuration of room or furnishings, provide overhead stop.
 - 3. Stop is not required if positive stop feature is specified for door closer; positive stop feature of door closer is not an acceptable substitute for a stop unless specifically so stated.

2.09 GASKETING AND THRESHOLDS

- A. Gaskets: Complying with BHMA A156.22.
 - 1. On each door in smoke partition, provide smoke gaskets; top, sides, and meeting stile of pairs. If fire/smoke partitions are not indicated on drawings, provide smoke gaskets on each door identified as a "smoke door" and 20-minute rated fire doors.
 - 2. On each exterior door, provide weatherstripping gaskets, unless otherwise indicated; top, sides, and meeting stiles of pairs.
 - a. Where exterior door is also required to have fire or smoke rating, provide gaskets functioning as both smoke and weather seals.
 - 3. On each exterior door, provide door bottom sweep, unless otherwise indicated.
- B. Thresholds: Complying with BHMA A156.21.
 - 1. At each exterior door, provide a threshold unless otherwise indicated.

2.10 PROTECTION PLATES AND ARCHITECTURAL TRIM

- A. Protection Plates:
 - 1. Kickplate: Provide on push side of every door with closer, except aluminum storefront and glass entry doors.

2.11 KEY CONTROLS

- A. Key Management System: For each keyed lock on project, provide one set of consecutively numbered duplicate key tags with hanging hole and snap catch.
 - 1. Security Key Tags: For each keyed lock on project, provide one set of matching key tags for permanent attachment to one key of each set.
 - 2. Provide key collection envelopes, receipt cards, and index cards in quantity suitable to number of keys to be managed.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that doors and frames are ready to receive work; labeled, fire-rated doors and frames are present and properly installed, and dimensions are as indicated on shop drawings.

3.02 INSTALLATION

- A. Install hardware in accordance with manufacturer's instructions and applicable codes.
- B. Use templates provided by hardware item manufacturer.

- C. Install hardware on fire-rated doors and frames in accordance with code and NFPA 80.
- D. Mounting heights for hardware from finished floor to center line of hardware item.
 - 1. For steel doors and frames: Comply with DHI "Recommended Locations for Architectural Hardware for Steel Doors and Frames."
 - 2. For Steel Doors and Frames: Refer to Section 08 11 13.
- E. Set exterior door thresholds with full-width bead of elastomeric sealant on each point of contact with floor providing a continuous weather seal; anchor thresholds with stainless steel countersunk screws.

3.03 ADJUSTING

- A. Adjust work under provisions of Section 01 70 00.
- B. Adjust hardware for smooth operation.

3.04 CLEANING

- A. Clean adjacent surfaces soiled by hardware installation. Clean finished hardware per manufacturer's instructions after final adjustments has been made. Replace items that cannot be cleaned to manufacturer's level of finish quality at no additional cost.

3.05 PROTECTION

- A. Protect finished Work under provisions of Section 01 70 00.
- B. Do not permit adjacent work to damage hardware or finish.

END OF SECTION

SECTION 08 91 00
LOUVERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Louvers, frames, and accessories.

1.02 REFERENCE STANDARDS

- A. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum; American Architectural Manufacturers Association; 2012.
- B. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels; 2013.
- C. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; Air Movement and Control Association International, Inc.; 2012.
- D. AMCA 511 - Certified Ratings Program Product Rating Manual for Air Control Devices; 2013.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data describing design characteristics, maximum recommended air velocity, design free area, materials and finishes.
- C. Shop Drawings: Indicate louver layout plan and elevations, opening and clearance dimensions, tolerances; head, jamb and sill details; blade configuration, screens, blankout areas required, and frames.
- D. Test Reports: Independent agency reports showing compliance with specified performance criteria.
- E. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- F. Maintenance Data: Include lubrication schedules, adjustment requirements.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.

1.05 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide twenty year manufacturer warranty against distortion, metal degradation, and failure of connections.
 - 1. Finish: Include coverage against degradation of exterior finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Wall Louvers:
 - 1. Ruskin: ELF6375XH (extruded aluminum): www.ruskin.com
 - 2. Substitutions: Not permitted.

2.02 LOUVERS

- A. Louvers: Factory fabricated and assembled, complete with frame, mullions, and accessories; AMCA Certified in accordance with AMCA 511.
 - 1. Wind Load Resistance: Design to resist positive and negative wind load of 25 psf (1.2 kPa) without damage or permanent deformation.
 - 2. Intake Louvers: Design to allow maximum of 0.01 oz/sq ft (3.1 g/sq m) water penetration at calculated intake design velocity based on design air flow and actual free area, when tested in accordance with AMCA 500-L.

3. Drainable Blades: Continuous rain stop at front or rear of blade aligned with vertical gutter recessed into both jambs of frame.
 4. Screens: Provide insect screens at intake louvers and bird screens at exhaust louvers.
- B. Stationary Louvers, Type ____: Horizontal blade, formed galvanized steel sheet construction, with intermediate mullions matching frame.
1. Blades: Straight.
 2. Frame: 6 inches (150 mm) deep, channel profile; corner joints mitered and, with continuous recessed caulking channel each side.
 3. Aluminum Thickness: Frame 12 gage, 0.0808 inch (2.05 mm) minimum; blades 12 gage, 0.0808 inch (2.05 mm) minimum.
 4. Steel Finish: Superior performing organic coatings, finished after fabrication.

2.03 MATERIALS

- A. Extruded Aluminum: ASTM B221 (ASTM B221M).

2.04 FINISHES

- A. Class I Color Anodized Finish: AAMA 611 AA-M12C22A42 Integrally colored anodic coating not less than 0.7 mils (0.018 mm) thick.
- B. Superior Performing Organic Coatings: AAMA 2605 multiple coat, thermally cured polyvinylidene fluoride system.
1. Polyvinylidene fluoride (PVDF) multi-coat thermoplastic fluoropolymer coating system, including minimum 70 percent PVDF color topcoat and minimum total dry film thickness of 0.9 mil (0.023 mm); color and gloss as indicated on drawings.

2.05 ACCESSORIES

- A. Screens: Frame of same material as louver, with reinforced corners; removable, screw attached; installed on inside face of louver frame.
- B. Bird Screen: Interwoven wire mesh of steel, 14 gage, 0.0641 inch (1.63 mm) diameter wire, 1/2 inch (13 mm) open weave, diagonal design.
- C. Flashings: Of same material as louver frame, formed to required shape, single length in one piece per location.
- D. Sealant for Setting Sills and Sill Flashing: Non-curing butyl type.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that prepared openings and flashings are ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that field measurements are as indicated.

3.02 INSTALLATION

- A. Install louver assembly in accordance with manufacturer's instructions.
- B. Install louvers level and plumb.
- C. Install flashings and align louver assembly to ensure moisture shed from flashings and diversion of moisture to exterior.
- D. Secure louver frames in openings with concealed fasteners.

3.03 CLEANING

- A. Strip protective finish coverings.
- B. Clean surfaces and components.

END OF SECTION

SECTION 09 21 16
GYPHUM BOARD ASSEMBLIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Performance criteria for gypsum board assemblies.
- B. Metal stud wall framing.
- C. Metal channel ceiling framing.
- D. Acoustic insulation.
- E. Cementitious backing board.
- F. Gypsum wallboard.
- G. Joint treatment and accessories.

1.02 RELATED REQUIREMENTS

- A. Section 01 61 16 - Volatile Organic Compound (VOC) Content Restrictions.
- B. Section 06 10 00 - Rough Carpentry: Wood blocking product and execution requirements.
- C. Section 07 92 00 - Joint Sealants: Sealing acoustical gaps in construction other than gypsum board or plaster work.
- D. Section 09 30 00 - Tiling: Tile backing board.

1.03 REFERENCE STANDARDS

- A. ANSI A108.11 - American National Standard for Interior Installation of Cementitious Backer Units; 2010 (Revised).
- B. ANSI A118.9 - American National Standard Specifications for Test Methods and Specifications for Cementitious Backer Units; 1999 (Reaffirmed 2010).
- C. ASTM C475/C475M - Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board; 2015.
- D. ASTM C645 - Standard Specification for Nonstructural Steel Framing Members; 2014.
- E. ASTM C665 - Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing; 2012.
- F. ASTM C754 - Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products; 2015.
- G. ASTM C840 - Standard Specification for Application and Finishing of Gypsum Board; 2013.
- H. ASTM C954 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs From 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness; 2015.
- I. ASTM C1002 - Standard Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs; 2014.
- J. ASTM C1047 - Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base; 2014a.
- K. ASTM C1325 - Standard Specification for Non-Asbestos Fiber-Mat Reinforced Cement Substrate Sheets; 2014.
- L. ASTM C1396/C1396M - Standard Specification for Gypsum Board; 2014.
- M. ASTM D3273 - Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber; 2012.
- N. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements; 2009.

- O. ASTM E413 - Classification for Rating Sound Insulation; 2010.
- P. GA-216 - Application and Finishing of Gypsum Board; Gypsum Association; 2013.

PART 2 PRODUCTS

2.01 GYPSUM BOARD ASSEMBLIES

- A. Provide completed assemblies complying with ASTM C840 and GA-216.
- B. Interior Partitions, Indicated as Acoustic: Provide completed assemblies with the following characteristics:
 - 1. Acoustic Attenuation: STC of 45-49 calculated in accordance with ASTM E413, based on tests conducted in accordance with ASTM E90.

2.02 METAL FRAMING MATERIALS

- A. Manufacturers - Metal Framing, Connectors, and Accessories:
 - 1. Clarkwestern Dietrich Building Systems LLC; ____: www.clarkdietrich.com.
- B. Non-Loadbearing Framing System Components: ASTM C645; galvanized sheet steel, of size and properties necessary to comply with ASTM C754 for the spacing indicated, with maximum deflection of wall framing of L/240 at 5 psf (L/240 at 240 Pa).
 - 1. Studs: "C" shaped with flat or formed webs with knurled faces.
 - 2. Runners: U shaped, sized to match studs.
 - 3. Ceiling Channels: C-shaped.
 - 4. Furring: Hat-shaped sections, minimum depth of 7/8 inch (22 mm).
- C. Ceiling Hangers: Type and size as specified in ASTM C754 for spacing required.

2.03 BOARD MATERIALS

- A. Manufacturers - Gypsum-Based Board:
 - 1. American Gypsum Company; ____: www.americangypsum.com.
 - 2. CertainTeed Corporation; ____: www.certainteed.com.
 - 3. USG Corporation; ____: www.usg.com.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Gypsum Wallboard: Paper-faced gypsum panels as defined in ASTM C1396/C1396M; sizes to minimize joints in place; ends square cut.
 - 1. Application: Use for vertical surfaces and ceilings, unless otherwise indicated.
 - 2. Thickness:
 - a. Vertical Surfaces: 5/8 inch (16 mm).
 - b. Ceilings: 5/8 inch (16 mm).
- C. Backing Board For Wet Areas: One of the following products:
 - 1. Application: Surfaces behind tile in wet areas including water closet and sink locations_____.
 - 2. Mold Resistance: Score of 10, when tested in accordance with ASTM D3273.
 - 3. ANSI Cement-Based Board: Non-gypsum-based; aggregated Portland cement panels with glass fiber mesh embedded in front and back surfaces complying with ANSI A118.9 or ASTM C1325.
 - a. Thickness: 1/2 inch (12.7 mm).
 - b. Products:
 - 1) USG Corporation; ____: www.usg.com.
 - 2) Substitutions: See Section 01 60 00 - Product Requirements.

2.04 ACCESSORIES

- A. Acoustic Insulation: ASTM C665; preformed glass fiber, friction fit type, unfaced. Thickness: 1-1/2 inches. (Thickness: 38 mm.)
- B. Acoustic Sealant: Acrylic emulsion latex or water-based elastomeric sealant; do not use solvent-based non-curing butyl sealant.

- C. Beads, Joint Accessories, and Other Trim: ASTM C1047, rigid plastic, galvanized steel, or rolled zinc, unless noted otherwise.
 - 1. Rigid Corner Beads: Low profile, for 90 degree outside corners and archways.
- D. Joint Materials: ASTM C475 and as recommended by gypsum board manufacturer for project conditions.
- E. Screws for Fastening of Gypsum Panel Products to Cold-Formed Steel Studs Less than 0.033 inch (0.84 mm) in Thickness and Wood Members: ASTM C1002; self-piercing tapping screws, corrosion resistant.
- F. Screws for Fastening of Gypsum Panel Products to Steel Members from 0.033 to 0.112 inch (0.84 to 2.84 mm) in Thickness: ASTM C954; steel drill screws, corrosion resistant.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that project conditions are appropriate for work of this section to commence.

3.02 FRAMING INSTALLATION

- A. Metal Framing: Install in accordance with ASTM C754 and manufacturer's instructions.
- B. Suspended Ceilings and Soffits: Space framing and furring members as indicated.
- C. Studs: Space studs as scheduled.
 - 1. Extend partition framing to structure where indicated and to ceiling in other locations.
 - 2. Partitions Terminating at Ceiling: Attach ceiling runner securely to ceiling track in accordance with manufacturer's instructions.
- D. Blocking: Install wood blocking for support of:
 - 1. Plumbing fixtures.
 - 2. Toilet accessories.

3.03 ACOUSTIC ACCESSORIES INSTALLATION

- A. Acoustic Insulation: Place tightly within spaces, around cut openings, behind and around electrical and mechanical items within partitions, and tight to items passing through partitions.
- B. Acoustic Sealant: Install in accordance with manufacturer's instructions.

3.04 BOARD INSTALLATION

- A. Comply with ASTM C 840, GA-216, and manufacturer's instructions. Install to minimize butt end joints, especially in highly visible locations.
- B. Single-Layer Non-Rated: Install gypsum board in most economical direction, with ends and edges occurring over firm bearing.
- C. Fire-Rated Construction: Install gypsum board in strict compliance with requirements of assembly listing.
- D. Cementitious Backing Board: Install over steel framing members and plywood substrate where indicated, in accordance with ANSI A108.11 and manufacturer's instructions.

3.05 INSTALLATION OF TRIM AND ACCESSORIES

- A. Control Joints: Place control joints consistent with lines of building spaces and as indicated.
- B. Corner Beads: Install at external corners, using longest practical lengths.
- C. Edge Trim: Install at locations where gypsum board abuts dissimilar materials.

3.06 JOINT TREATMENT

- A. Finish gypsum board in accordance with levels defined in ASTM C840, as follows:
 - 1. Level 4: Walls and ceilings to receive paint finish or wall coverings, unless otherwise indicated.
 - 2. Level 1: Fire rated wall areas above finished ceilings, whether or not accessible in the completed construction.

- B. Tape, fill, and sand exposed joints, edges, and corners to produce smooth surface ready to receive finishes.
 - 1. Feather coats of joint compound so that camber is maximum 1/32 inch (0.8 mm).

3.07 TOLERANCES

- A. Maximum Variation of Finished Gypsum Board Surface from True Flatness: 1/8 inch in 10 feet (3 mm in 3 m) in any direction.

END OF SECTION

SECTION 09 30 00
TILING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Tile for floor applications.
- B. Tile for wall applications.
- C. Stone thresholds.
- D. Ceramic trim.

1.02 REFERENCE STANDARDS

- A. ANSI A108/A118/A136.1 - American National Standard Specifications for the Installation of Ceramic Tile - Version; 2014.
- B. ANSI A108.1A - American National Standard Specifications for Installation of Ceramic Tile in the Wet-Set Method, with Portland Cement Mortar; 2014.
- C. ANSI A108.1B - American National Standard Specifications for Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex-Portland Cement Mortar; 1999 (Reaffirmed 2010).
- D. ANSI A108.1C - Specifications for Contractors 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 Bed with Dry-Set or Latex-Portland Cement Mortar; 1999 (Reaffirmed 2010).
- E. ANSI A108.4 - American National Standard Specifications for Installation of Ceramic Tile with Organic Adhesives or Water Cleanable Tile-Setting Epoxy Adhesive; 2009 (Revised).
- F. ANSI A108.5 - American National Standard Specifications for Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar; 1999 (Reaffirmed 2010).
- G. ANSI A108.6 - American National Standard Specifications for Installation of Ceramic Tile with Chemical Resistant, Water Cleanable Tile-Setting and -Grouting Epoxy; 1999 (Reaffirmed 2010).
- H. ANSI A108.8 - American National Standard Specifications for Installation of Ceramic Tile with Chemical Resistant Furan Resin Mortar and Grout; 1999 (Reaffirmed 2010).
- I. ANSI A108.9 - American National Standard Specifications for Installation of Ceramic Tile with Modified Epoxy Emulsion Mortar/Grout; 1999 (Reapproved 2010).
- J. ANSI A108.10 - American National Standard Specifications for Installation of Grout in Tilework; 1999 (Reapproved 2010).
- K. ANSI A108.11 - American National Standard Specifications for Interior Installation of Cementitious Backer Units; 2010 (Revised).
- L. ANSI A108.12 - American National Standard Specifications for Installation of Ceramic Tile with EGP (Exterior Glue Plywood) Latex-Portland Cement Mortar; 1999 (Reaffirmed 2010).
- M. ANSI A108.13 - American National Standard Specifications for Installation of Load Bearing, Bonded, Waterproof Membranes for Thin-Set Ceramic Tile and Dimension Stone; 2005 (Reaffirmed 2010).
- N. ANSI A118.6 - American National Standard Specifications for Standard Cement Grouts for Tile Installation; 2010 (Revised).
- O. ANSI A137.1 - American National Standard Specifications for Ceramic Tile - Version; 2013.1.
- P. ASTM C373 - Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products, Ceramic Tiles, and Glass Tiles; 2014a.

Q. TCNA (HB) - Handbook for Ceramic, Glass, and Stone Tile Installation; 2015.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers' data sheets on tile, mortar, grout, and accessories. Include instructions for using grouts and adhesives.

1.04 QUALITY ASSURANCE

- A. Maintain one copy of and ANSI A108/A118/A136.1 and TCNA (HB) on site.
- B. Manufacturer Qualifications: Company specializing in manufacturing the types of products specified in this section, with minimum five years of documented experience.
- C. Installer Qualifications: Company specializing in performing tile installation, with minimum of five years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect adhesives from freezing or overheating in accordance with manufacturer's instructions.

1.06 FIELD CONDITIONS

- A. Do not install solvent-based products in an unventilated environment.
- B. Maintain ambient and substrate temperature of 50 degrees F (10 degrees C) during installation of mortar materials.

PART 2 PRODUCTS

2.01 TILE

- A. Manufacturers: All products by the same manufacturer.
 - 1. Dal-Tile Corporation: www.daltile.com.
- B. Ceramic Mosaic Tile: ANSI A137.1, standard grade.
 - 1. Moisture Absorption: 0 to 0.5 percent as tested in accordance with ASTM C373.
 - 2. Size: 2 by 2 inch (51 by 51 mm), nominal.
 - 3. Shape: Square.
 - 4. Edges: Square.
 - 5. Surface Finish: Unglazed.
 - 6. Color(s): As shown on drawings.
 - 7. Trim Units: Matching bead, cove, and surface bullnose shapes in sizes coordinated with field tile.

2.02 TRIM AND ACCESSORIES

- A. Ceramic Trim: Matching bullnose, double bullnose, cove base, and cove ceramic shapes in sizes coordinated with field tile.
 - 1. Applications:
 - a. Open Edges: Bullnose.
 - b. Inside Corners: Jointed.
 - c. Floor to Wall Joints: Cove base.
 - 2. Manufacturers: Same as for tile.
- B. Thresholds: Marble, gray, honed finish; 2 inches (51 mm) wide by full width of wall or frame opening; 1/2 inch thick (12.7 mm thick); beveled one long edge with radiused corners on top side; without holes, cracks, or open seams.

2.03 SETTING MATERIALS

- A. Manufacturers:
 - 1. LATICRETE International, Inc; _____: www.laticrete.com.

2.04 GROUTS

- A. Manufacturers:

1. LATICRETE International, Inc; LATICRETE PERMACOLOR Grout: www.laticrete.com.
- B. Standard Grout: ANSI A118.6 standard cement grout.
 1. Applications: Use this type of grout where indicated and where no other type of grout is indicated.
 2. Use sanded grout for joints 1/8 inch wide and larger; use unsanded grout for joints less than 1/8 inch wide.
 3. Color(s): As scheduled.
 4. Products:
 - a. LATICRETE International, Inc; LATICRETE 1500 Sanded Grout: www.laticrete.com.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that sub-floor surfaces are smooth and flat within the tolerances specified for that type of work and are ready to receive tile.
- B. Verify that wall surfaces are smooth and flat within the tolerances specified for that type of work, are dust-free, and are ready to receive tile.
- C. Verify that sub-floor surfaces are dust-free and free of substances that could impair bonding of setting materials to sub-floor surfaces.

3.02 PREPARATION

- A. Protect surrounding work from damage.
- B. Vacuum clean surfaces and damp clean.
- C. Seal substrate surface cracks with filler. Level existing substrate surfaces to acceptable flatness tolerances.

3.03 INSTALLATION - GENERAL

- A. Install tile, thresholds, and stair treads and grout in accordance with applicable requirements of ANSI A108.1a thru A108.13, manufacturer's instructions, and TCNA (HB) recommendations.
- B. Lay tile to pattern indicated. Do not interrupt tile pattern through openings.
- C. Cut and fit tile to penetrations through tile, leaving sealant joint space. Form corners and bases neatly. Align floor joints.
- D. Place tile joints uniform in width, subject to variance in tolerance allowed in tile size. Make grout joints without voids, cracks, excess mortar or excess grout, or too little grout.
- E. Form internal angles square and external angles bullnosed.
- F. Install thresholds where indicated.
- G. Sound tile after setting. Replace hollow sounding units.
- H. Keep control and expansion joints free of mortar, grout, and adhesive.
- I. Prior to grouting, allow installation to completely cure; minimum of 48 hours.
- J. Grout tile joints unless otherwise indicated. Use standard grout unless otherwise indicated.
- K. At changes in plane and tile-to-tile control joints, use tile sealant instead of grout, with either bond breaker tape or backer rod as appropriate to prevent three-sided bonding.

3.04 INSTALLATION - FLOORS - THIN-SET METHODS

- A. Over interior concrete substrates, install in accordance with TCNA (HB) Method F113, dry-set or latex-Portland cement bond coat, with standard grout, unless otherwise indicated.

3.05 INSTALLATION - FLOORS - MORTAR BED METHODS

- A. Over interior concrete substrates, install in accordance with TCNA (HB) Method F111, with cleavage membrane, unless otherwise indicated.
- B. Cleavage Membrane: Lap edges and ends.

- C. Mortar Bed Thickness: 5/8 inch (15.9 mm), unless otherwise indicated.

3.06 INSTALLATION - WALL TILE

- A. Over cementitious backer units on studs, install in accordance with TCNA (HB) Method W244, using membrane at toilet rooms.
- B. Over interior concrete and masonry install in accordance with TCNA (HB) Method W202, thin-set with dry-set or latex-Portland cement bond coat.

3.07 CLEANING

- A. Clean tile and grout surfaces.

3.08 PROTECTION

- A. Do not permit traffic over finished floor surface for 4 days after installation.

END OF SECTION

SECTION 09 51 00
SUSPENDED ACOUSTICAL CEILINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Suspended metal grid ceiling system.
- B. Acoustical units.

1.02 RELATED REQUIREMENTS

- A. Section 01 61 16 - Volatile Organic Compound (VOC) Content Restrictions.
- B. Section 08 31 00 - Access Doors and Panels: Access panels.
- C. Section 21 13 00 - Fire Suppression Sprinklers: Sprinkler heads in ceiling system.
- D. Section 23 37 00 - Air Outlets and Inlets: Air diffusion devices in ceiling.
- E. Section 26 51 00 - Interior Lighting: Light fixtures in ceiling system.
- F. Section 27 51 17 - Public Address Systems: Speakers in ceiling system.
- G. Section 28 31 00 - Fire Detection and Alarm: Fire alarm components in ceiling system.

1.03 REFERENCE STANDARDS

- A. ASTM C635/C635M - Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings; 2013a.
- B. ASTM C636/C636M - Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels; 2013.
- C. ASTM E1264 - Standard Classification for Acoustical Ceiling Products; 2014.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Sequence work to ensure acoustical ceilings are not installed until building is enclosed, sufficient heat is provided, dust generating activities have terminated, and overhead work is completed, tested, and approved.
- B. Do not install acoustical units until after interior wet work is dry.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on suspension system components.
- C. Samples: Submit two samples each, ____ inches (____ mm) long, of suspension system main runner.
- D. Manufacturer's Installation Instructions: Indicate special procedures.

1.06 QUALITY ASSURANCE

- A. Suspension System Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- B. Acoustical Unit Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.07 FIELD CONDITIONS

- A. Maintain uniform temperature of minimum 60 degrees F (16 degrees C), and maximum humidity of 40 percent prior to, during, and after acoustical unit installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acoustic Panels:
 - 1. Armstrong World Industries, Inc; ____: www.armstrong.com.

2. USG; ____: www.usg.com.
3. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 ACOUSTICAL UNITS

- A. Acoustical Units - General: ASTM E1264, Class A.
- B. Acoustical Panels Type ____: ____.
 1. VOC Content: As specified in Section 01 61 16.
 2. Size: 24 by 24 inches (600 by 600 mm).

2.03 SUSPENSION SYSTEM(S)

- A. Suspension Systems - General: Complying with ASTM C635/C635M; die cut and interlocking components, with stabilizer bars, clips, splices, perimeter moldings, and hold down clips as required.
- B. Exposed Steel Suspension System Type ____: Formed steel, commercial quality cold rolled; heavy-duty.
 1. Profile: Tee; 9/16 inch (14 mm) wide face.
 2. Construction: Double web.
 3. Finish: White painted.

2.04 ACCESSORIES

- A. Support Channels and Hangers: Galvanized steel; size and type to suit application, seismic requirements, and ceiling system flatness requirement specified.
- B. Perimeter Moldings: Same material and finish as grid.
 1. At Exposed Grid: Provide L-shaped molding for mounting at same elevation as face of grid.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that layout of hangers will not interfere with other work.

3.02 INSTALLATION - SUSPENSION SYSTEM

- A. Install suspension system in accordance with ASTM C636/C636M and manufacturer's instructions and as supplemented in this section.
- B. Rigidly secure system, including integral mechanical and electrical components, for maximum deflection of 1:360.
- C. Locate system on room axis according to reflected plan.
- D. Install after major above-ceiling work is complete. Coordinate the location of hangers with other work.
- E. Hang suspension system independent of walls, columns, ducts, pipes and conduit. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.
- F. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.
- G. Do not support components on main runners or cross runners if weight causes total dead load to exceed deflection capability.
- H. Support fixture loads using supplementary hangers located within 6 inches (150 mm) of each corner, or support components independently.
- I. Do not eccentrically load system or induce rotation of runners.
- J. Perimeter Molding: Install at intersection of ceiling and vertical surfaces and at junctions with other interruptions.
 1. Use longest practical lengths.

2. Overlap and rivet corners.

3.03 INSTALLATION - ACOUSTICAL UNITS

- A. Install acoustical units in accordance with manufacturer's instructions.
- B. Fit acoustical units in place, free from damaged edges or other defects detrimental to appearance and function.
- C. Fit border trim neatly against abutting surfaces.
- D. Install units after above-ceiling work is complete.
- E. Install acoustical units level, in uniform plane, and free from twist, warp, and dents.
- F. Cutting Acoustical Units:
 1. Make field cut edges of same profile as factory edges.

3.04 TOLERANCES

- A. Maximum Variation from Flat and Level Surface: 1/8 inch in 10 feet (3 mm in 3 m).
- B. Maximum Variation from Plumb of Grid Members Caused by Eccentric Loads: 2 degrees.

END OF SECTION

SECTION 09 68 13
TILE CARPETING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Carpet tile, fully adhered.

1.02 RELATED REQUIREMENTS

- A. Section 01 61 16 - Volatile Organic Compound (VOC) Content Restrictions.

1.03 REFERENCE STANDARDS

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on specified products, describing physical and performance characteristics; sizes, patterns, colors available, and method of installation.
- C. Samples: Submit two carpet tiles illustrating color and pattern design for each carpet color selected.
- D. Manufacturer's Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.
- E. Maintenance Data: Include maintenance procedures, recommended maintenance materials, and suggested schedule for cleaning.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
 - 2. Extra Carpet Tiles: Quantity equal to 5 percent of total installed of each color and pattern installed.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing specified carpet tile with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in installing carpet tile with minimum three years documented experience and approved by carpet tile manufacturer.

1.06 FIELD CONDITIONS

- A. Store materials in area of installation for minimum period of 24 hours prior to installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Tile Carpeting:
 - 1. Interface, Inc; ____: www.interfaceinc.com.

2.02 MATERIALS

- A. Tile Carpeting: Tufted, manufactured in one color dye lot.

2.03 ACCESSORIES

- A. Edge Strips: Embossed aluminum, _____ color.
- B. Adhesives:
 - 1. Compatible with materials being adhered; maximum VOC content as specified in Section 01 61 16.
- C. Carpet Tile Adhesive: Recommended by carpet tile manufacturer; releasable type.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that sub-floor surfaces are smooth and flat within tolerances specified for that type of work and are ready to receive carpet tile.
- B. Verify that wall surfaces are smooth and flat within the tolerances specified for that type of work, are dust-free, and are ready to receive carpet tile.
- C. Verify that sub-floor surfaces are dust-free and free of substances that could impair bonding of adhesive materials to sub-floor surfaces.
- D. Cementitious Sub-floor Surfaces: Verify that substrates are dry enough and ready for flooring installation by testing for moisture and pH.
 - 1. Obtain instructions if test results are not within limits recommended by flooring material manufacturer and adhesive materials manufacturer.

3.02 PREPARATION

3.03 INSTALLATION

- A. Starting installation constitutes acceptance of sub-floor conditions.
- B. Install carpet tile in accordance with manufacturer's instructions.
- C. Blend carpet from different cartons to ensure minimal variation in color match.
- D. Cut carpet tile clean. Fit carpet tight to intersection with vertical surfaces without gaps.
- E. Lay carpet tile in square pattern, with pile direction parallel to next unit, set parallel to building lines.
- F. Fully adhere carpet tile to substrate.
- G. Trim carpet tile neatly at walls and around interruptions.
- H. Complete installation of edge strips, concealing exposed edges.

END OF SECTION

SECTION 09 91 23
INTERIOR PAINTING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Surface preparation.
- B. Field application of paints, stains, and varnishes.
- C. Scope: Finish interior surfaces exposed to view, unless fully factory-finished and unless otherwise indicated.
- D. Do Not Paint or Finish the Following Items:
 - 1. Items factory-finished unless otherwise indicated; materials and products having factory-applied primers are not considered factory finished.
 - 2. Items indicated to receive other finishes.
 - 3. Items indicated to remain unfinished.
 - 4. Fire rating labels, equipment serial number and capacity labels, bar code labels, and operating parts of equipment.
 - 5. Floors, unless specifically indicated.
 - 6. Glass.
 - 7. Concealed pipes, ducts, and conduits.

1.02 RELATED REQUIREMENTS

- A. Section 01 61 16 - Volatile Organic Compound (VOC) Content Restrictions.

1.03 DEFINITIONS

- A. Conform to ASTM D16 for interpretation of terms used in this section.

1.04 REFERENCE STANDARDS

- A. ASTM D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications; 2014.
- B. MPI (APSM) - Master Painters Institute Architectural Painting Specification Manual; current edition, www.paintinfo.com.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide complete list of products to be used, with the following information for each:
 - 1. Manufacturer's name, product name and/or catalog number, and general product category (e.g. "alkyd enamel").
 - 2. MPI product number (e.g. MPI #47).
 - 3. Cross-reference to specified paint system(s) product is to be used in; include description of each system.
- C. Samples: Submit three paper "draw down" samples, 8-1/2 by 11 inches (216 by 279 mm) in size, illustrating range of colors available for each finishing product specified.
 - 1. Where sheen is specified, submit samples in only that sheen.
 - 2. Where sheen is not specified, submit each color in each sheen available.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified, with minimum three years documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified with minimum five years experience and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.
- B. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- C. Paint Materials: Store at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

1.08 FIELD CONDITIONS

- A. Do not apply materials when surface and ambient temperatures are outside the temperature ranges required by the paint product manufacturer.
- B. Follow manufacturer's recommended procedures for producing best results, including testing of substrates, moisture in substrates, and humidity and temperature limitations.
- C. Provide lighting level of 80 ft candles (860 lx) measured mid-height at substrate surface.

PART 3 EXECUTION

2.01 PREPARATION

- A. Clean surfaces thoroughly and correct defects prior to application.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- C. Remove or mask surface appurtenances, including electrical plates, hardware, light fixture trim, escutcheons, and fittings, prior to preparing surfaces or finishing.
- D. Seal surfaces that might cause bleed through or staining of topcoat.
- E. Gypsum Board: Fill minor defects with filler compound. Spot prime defects after repair.

2.02 APPLICATION

- A. Apply products in accordance with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual".
- B. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.
- C. Apply each coat to uniform appearance in thicknesses specified by manufacturer.
- D. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.
- E. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.

2.03 SCHEDULE - PAINT SYSTEMS

END OF SECTION

SECTION 10 14 00
SIGNAGE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Luminous egress path marking and other "glow-in-the-dark" signs.

1.02 REFERENCE STANDARDS

- A. UL 1994 - Luminous Egress Path Marking Systems; Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Samples: Submit two samples of each type of sign, of size similar to that required for project, illustrating sign style, font, and method of attachment.
- C. Manufacturer's Installation Instructions: Include installation templates and attachment devices.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.

1.04 DELIVERY, STORAGE, AND HANDLING

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Photoluminescent Marking and Signage:
 - 1. Johnsonite SafeTFirst P44151 Black Diagonal Guidance Tape; www.johnsonite.com.
 - 2. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 SIGNAGE APPLICATIONS

- A. Luminous Egress Path Marking and Other "Glow-in-the-Dark" Signs: Photoluminescent media.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install neatly, with horizontal edges level.
- C. Locate signs where indicated:
 - 1. If no location is indicated obtain Owner's instructions.
- D. Protect from damage until Substantial Completion; repair or replace damage items.

END OF SECTION

SECTION 10 28 00
TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Accessories for toilet rooms.
- B. Grab bars.

1.02 RELATED REQUIREMENTS

- A. Section 06 10 00 - Rough Carpentry: Concealed supports for accessories, including in wall framing and plates.
- B. Section 08 83 00 - Mirrors: Other mirrors.

1.03 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design; 2010.
- B. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2015.
- C. ASTM A269/A269M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service; 2015.
- D. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2015.
- E. ASTM C1036 - Standard Specification for Flat Glass; 2011e1.
- F. ASTM C1503 - Standard Specification for Silvered Flat Glass Mirror; 2008 (Reapproved 2013).

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit data on accessories describing size, finish, details of function, and attachment methods.
- C. Manufacturer's Installation Instructions: Indicate special procedures and conditions requiring special attention.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Toilet Accessories:
 - 1. ASI - American Specialties, Inc; _____: www.americanspecialties.com.
 - 2. Bradley Corporation; _____: www.bradleycorp.com.
 - 3. Brobrick Washroom Equipment; www.brobrick.com.

2.02 MATERIALS

- A. Accessories - General: Shop assembled, free of dents and scratches and packaged complete with anchors and fittings, steel anchor plates, adapters, and anchor components for installation.
 - 1. Grind welded joints smooth.
 - 2. Fabricate units made of metal sheet of seamless sheets, with flat surfaces.
- B. Keys: Provide two keys for each accessory to Owner; master key lockable accessories.
- C. Stainless Steel Sheet: ASTM A666, Type 304.
- D. Stainless Steel Tubing: ASTM A269/A269M, Type 304 or 316.
- E. Mirror Glass: Annealed float glass, ASTM C1036 Type I, Class 1, Quality Q2, with silvering, protective and physical characteristics complying with ASTM C1503.
- F. Adhesive: Two component epoxy type, waterproof.
- G. Fasteners, Screws, and Bolts: Hot dip galvanized; tamper-proof; security type.

- H. Expansion Shields: Fiber, lead, or rubber as recommended by accessory manufacturer for component and substrate.

2.03 FINISHES

- A. Stainless Steel: No. 4 Brushed finish, unless otherwise noted.
- B. Galvanizing for Items Other than Sheet: Comply with ASTM A123/A123M; galvanize ferrous metal and fastening devices.
- C. Back paint components where contact is made with building finishes to prevent electrolysis.

2.04 TOILET ROOM ACCESSORIES

- A. Toilet Paper Dispenser: Double roll, surface mounted bracket type, chrome-plated zinc alloy brackets, spindleless type for tension spring delivery designed to prevent theft of tissue roll.
- B. Combination Towel Dispenser/Waste Receptacle: Recessed flush with wall, stainless steel; seamless wall flanges, continuous piano hinges, tumbler locks on upper and lower doors.
- C. Mirrors: Stainless steel framed, 1/4 inch (6 mm) thick annealed float glass; ASTM C1036.
 - 1. Annealed Float Glass: Silvering, protective and physical characteristics in compliance with ASTM C1503.
- D. Grab Bars: Stainless steel, nonslip grasping surface finish.
 - 1. Standard Duty Grab Bars:
 - a. Push/Pull Point Load: 250 pound-force (1112 N), minimum.
 - b. Dimensions: 1-1/4 inch (32 mm) outside diameter, minimum 0.05 inch (1.3 mm) wall thickness, exposed flange mounting, 1-1/2 inch (38 mm) clearance between wall and inside of grab bar.
 - c. Length and Configuration: As indicated on drawings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify exact location of accessories for installation.
- C. Verify that field measurements are as indicated on drawings.

3.02 PREPARATION

- A. Deliver inserts and rough-in frames to site for timely installation.
- B. Provide templates and rough-in measurements as required.

3.03 INSTALLATION

- A. Install accessories in accordance with manufacturers' instructions in locations indicated on the drawings.
- B. Install plumb and level, securely and rigidly anchored to substrate.
- C. Mounting Heights: As required by accessibility regulations, unless otherwise indicated.
 - 1. Grab Bars: As indicated on the drawings.
 - 2. Mirrors: 40" inch (____ mm), measured to bottom of mirrored surface.

END OF SECTION

SECTION 14 41 00
DOCK LIFT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Loading dock equipment of the following types:
 - 1. Dock lifts.

1.02 RELATED REQUIREMENTS

- A. Section 16050 - Basic Electrical Methods and Materials: Coordination with power requirements and controls/safety circuits
- B. Section 01 30 00 - Administrative Requirements: Submittal procedures, project meetings, progress schedules and documentation, reports, coordination.
- C. Section 01 78 00 - Closeout Submittals: Project record documents, operation and maintenance (O&M) data, warranties and bonds.

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI): ANSI MH29.1 Safety Requirements for Industrial Scissor Lifts.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings: Showing overall dimensions (width, height) and location of electrical service panels and motor locations. Supporting construction requirements and equipment structural attachment. Operating range and required clearances..

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Providing sole source for design, engineering, manufacturing and warranty claims handling. Company specializing in manufacturing products specified with a minimum 20 years experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified and with minimum three years of documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.

1.07 FIELD CONDITIONS

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

1.08 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Warranty: Provide manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 APPLICATIONS

- A. Low Profile Dock Lift: Deck Size - 60 inches (1524 mm) W by 96 inches (2438 mm) L. Lowered height - 10 inches (254 mm). Vertical Travel - 59 inches (1499 mm), Lift Speed - 14.0 fpm (4.25 mpm).
- B. Capacity: 5,000 lb (2268 kg).
- C. Provide retaining cradles and wear plates. Add 1/4 inch (6 mm) to low height.
- D. Provide toe sensor.
- E. Provide platform mounted push button control.
- F. Provide push button on coil cord.
- G. Provide two second warning bell (sounds prior to lift movement).
- H. Provide up / down key operated selector switch.
- I. Provide additional guard rails (platform or floor mount).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of Conditions: Do not begin installation until substrates have been properly prepared..

3.02 PREPARATION

- A. Surface Preparation:
 - 1. Clean surfaces thoroughly prior to installation..
 - 2. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions..

3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.04 PROTECTION

- A. Protect installed products from subsequent construction operations.

END OF SECTION

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SECTION 21 13 00

FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes requirements for providing a complete building fire protection sprinkler system and Class 1 standpipe system, coordinated with related. Section 21 13 13.

1.2 SYSTEM DESCRIPTIONS

- A. Types: The types of fire protection systems shall include, but not limited to, the following:
 - 1. Complete sprinkler system in accordance with NFPA 13, and the requirements of the State Fire Marshall. Refer to Section 21 13 13.
 - 2. The entire building shall be protected with a wet-pipe sprinkler system as specified in Section 21 13 13, Wet-Pipe Sprinkler System.
- B. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.
- C. Dry pipe sprinkler systems: Refer to Section 21 13 13.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For fire suppression automatic sprinkler systems and standpipe system, as indicated on the floor plans. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- D. Qualification Data: For qualified Installer and professional engineer.
- E. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- F. Welding certificates.
- G. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- H. Field quality-control reports.

- I. Operation and maintenance data.
- J. Provide Fire Inspection & Backflow reports to owner.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."
 - 2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

- A. General: All piping, fittings and valves shall be made in the USA and shall be stamped/stenciled "made in USA".
- B. Pipe: For aboveground, provide minimum schedule 40 steel pipe conforming to ASTM A795 or A53. For pipe sizes up to 2 inch, UL listed and FM approved Allied XL steel pipe rated for 300 psi may be used. Comply with applicable governing regulations and industry standards. Aboveground pipe and fittings upstream of double check valve assembly shall be schedule 40 galvanized steel conforming to ASTM A53 or ASTM A795 with grooved type joints as specified herein. For dry pipe systems and preaction systems provide schedule 40 steel pipe conforming to ASTM A53 or ASTM A795 with factory hot dipped zinc coated (galvanized) finish. Dry pipe and preaction system fittings shall also have galvanized finish. Fittings shall be threaded for pipe sizes up to 2 inch and grooved for pipe sizes over 2 inch.
- C. For underground pipe and fittings, provide PVC class 150 water pipe with integral bell and spigot joints, conforming to AWWA C900 and ASTM D1784 with a maximum pressure rating of 150 psi at 73 degrees F, UL listed for water mains, certified to ANSI/NSF Standard 61, with push on joints, conforming to ASTM D3139 and ASTM F477. Manufactured by "Blue Brute".
- D. Threaded Fittings: Class 150 malleable iron, ANSI B16.3.
- E. Malleable Iron Threaded Unions: ANSI B16.3, select for proper piping fabrication and service requirements including style, end connections, and metal-to-metal seats (iron, bronze, or brass), plain or galvanized as specified.

- F. Threaded Pipe Plugs: ANSI B16.14.
- G. Steel Flanges/Fittings: ANSI B16.5, including bolting, gasketing, and butt weld end connections. Fittings same thickness as pipe.
- H. Forged Steel Socket-welding and Threaded Fittings: ANSI B16.11, rated to match schedule of connected pipe.
- I. Wrought Steel Butt-welding Fittings: ANSI B16.9, except ANSI B16.28 for short radius elbows and returns; rated to match connected pipe.
- J. Flanged Fittings: Comply with ANSI B16.5 for bolt-hole dimensioning, materials, and flange thickness.
- K. Flange Bolts: Bolts shall be carbon steel ASTM A307 Grade A hexagon head bolts and hexagonal nuts. Where one or both flanges are cast iron, furnish Grade B bolts. Cap screws utilized with flanged butterfly valves shall be ASTM A307 Grade B with hexagon heads.
- L. Flange Bolt Thread Lubricant: Lubricant shall be an anti-seize compound designed for temperatures up to 1000°F and shall be Crane Anti-Seize Thread Compound or approved equal.
- M. Miscellaneous Piping Materials/Products:
 - 1. Welding Materials: Comply with ASME Boiler and Pressure Vessels Code, Section 11, Part C, for welding materials.
 - 2. Brazing Materials: American Welding Society, AWS A5.B, Classification B Cup-5.
 - 3. Gaskets for Flanged Joints: 1/16 inch thick for pipe size 10 inches and smaller and 1/8 inch thick for all pipe size 12 inches and larger. Ring-type shall be used between raised face flanges and full face-type between flat face flanges with punched bolt holes and pipe opening. Gaskets shall be Garlock Style 3400 compressed non-asbestos or equal.
 - 4. Dielectric Unions: Provide dielectric unions at all pipe connections between ferrous and nonferrous piping. Unions shall be "Delvin" as made by Pipeline Seal and Insulator Company or "EPCO" as made by Epcos Sales, Inc. and shall have nylon insulation.
- N. Use mechanical couplings may only be used for pipe sizes over 2 inches, to engage and lock grooved or pipe ends and to allow for some angular deflection, contraction and expansion.
 - 1. Couplings shall be positive lock type and shall consist of ASTM A536 ductile iron housing, c-shaped composition sealing gasket and carbon steel bolts conforming to ASTM A183.
 - 2. Gasket Material for wet systems shall be EPDM.
 - 3. Gasket material for dry pipe systems shall be silicone.
 - 4. All couplings shall be UL listed and FM approved.
 - 5. Provide only full flow (no-fabricated) fittings. Snap joint couplings, outlet couplings, cut-in style couplings, reducing couplings, mechanical-T style couplings, pressfit couplings, and plain end type couplings are not allowed.
 - 6. When mechanical couplings are used, ONLY grooved type fittings and pipe shall be used, no plain end fittings or pipe. Grooved couplings and fittings shall be manufactured by Victaulic, "Firelock" or approved equivalent.
- O. Flanges: All flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A 181 Grade 1 or Grade 2 or A-1 05-71 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges will not be acceptable. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition,

shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forgings or materials will not be acceptable. The flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Submit data for firm certifying compliance with these Specifications. Gaskets used shall be ring form, dimensioned to fit accurately within the bolt circle, shall be 1/16 inch thick, Manville service sheet packing Style 60. Inside diameter shall conform to the nominal pipe size. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. All-thread rods will not be an acceptable for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi. Flat faced flanges shall be furnished where required to match flanges on pumps, check valves, strainers, and similar items. Only one manufacturer of weld flanges will be approved for each project.

- P. Gaskets: Gaskets shall be placed between the flanges of all flange joints. Such gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges. Gaskets shall be 1/16" thick Manville Service Sheet Packing Style 60. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.
- Q. Unions in steel lines assembled with screwed fittings shall be malleable iron screwed pattern unions with bronze seats. Unions in copper or brass lines shall be all brass, threaded pattern unions. Where unions are required by the above in steel lines assembled by welding, they shall consist of two mating welding flanges. Dielectric unions shall be used at all junctures of dissimilar metals. Unions in 2 inch and smaller in ferrous lines shall be Class 300 AAR malleable iron unions with iron to brass seats, and 2-1/2 inch and larger shall be ground flange unions. Companion flanges on lines at various items of equipment, machines and pieces of apparatus shall serve as unions to permit removal of the particular items. See particular Specifications for special fittings and pressure.

2.2 FIRE PROTECTION SPECIALTIES

- A. Wall Mounted Fire Department Siamese Connection: Potter-Roemer Fig No. 5124-D-F, or approved equal, 4 x 2-1/2 x 2-1/2, 2-way, top outlet, clapper type fire department inlet polished chrome finish, cast brass construction, with sill cock flange plate and sill cock, labeled "Auto SPKR ", with ball drip. Complete with Knox FDC Cap Model No. 3010, lockable type chrome with all stainless steel caps with key wrench.
- B. Wall Type Post Indicating Valve: Wall mounted indicating post and valve, consisting of UL/ FM approved non-rising stem gate valve and indicating post. Gate valve shall have iron body with non-rising stem, bronze mounted, indicator post flange, 175 psi non-shock rating, flanged ends. Indicator post shall be free standing and shall have a cast iron body, plexiglass window and an 18 inch adjustment span with handle and locked and chained in open position. Manufactured by Mueller Valve No. A-2052 and Indicating Post No. A-20811, or approved equal.
- C. Valve Supervisory Switches:
 - 1. Provide on each valve, controlling or shutting-off sprinkler system where shown on drawings or/and on all valves required by NFPA 13, or any portion thereof.
 - 2. Provide UL listed unit, with either one single pole double throw switch or two single pole, double throw switches as required. Switch shall be compatible with installed valve for standard mounting. Manufactured by Potter Roemer No. 6220, or approved equal.

- D. Sight Flow Connection: Provide acrylic sight flow connection in all test lines, conforming to NFPA 13.
- E. Pressure Gauges: Potter-Roemer Fig. No. 6240 or approved equal 3-1/2 inch diameter polished brass case, 1/4 inch NPT male connection, glass enclosed, 0-300 psi dial pressure gauges with isolation valves.
- F. Fire Hose Cabinet: Recessed mounted cabinet consisting of 2-1/2" x 1-1/2" hose rack assembly with 100' polyflex hose, 20 gauge steel box, 20 gauge steel door, 18 gauge steel frame, continuous steel hinge, powder coated, recoatable white finish, dimensions – 26"W x 38"H x 8" deep, manufactured by Potter Roemer 1154, or approved equal.

2.3 VALVES

- A. General: All fire protection valves shall be UL-listed and FM-approved for fire protection use. All valves shall be of threaded, grooved or flanged type. No solder connected valves on water lines shall be used on this project. All bronze and iron body gate and globe valves shall be of one manufacture. Manufacturers of other types may not be mixed on the same project; i.e., all butterfly valves shall be of the same manufacture, all ball valves shall be of the same manufacture, etc. All valves at system points where the System Working Pressure (SWP) at the point of application, including appropriate pump shutoff head shall be rated for a minimum 175 psi water working pressure.
- B. Valves located with stem in horizontal position shall be drilled and tapped in accordance with MSS-SP-45 at Boss G to accommodate a drain valve. All valves shall be repackable, under pressure, with the valve in the full open position.
- C. Gate Valves: Gate valves 2 inches and smaller shall be 175 WOG rated, UL listed, FM-approved, all bronze outside screw and yoke, rising stem valves with solid wedges and threaded connections, manufactured by Nibco No. T-104-O, or approved equal. Valves 2-1/2 inches and larger shall be flanged, UL listed, FM-approved cast iron body (ASTM A-126), outside screw and yoke, rising stem gate valves with bolted bonnets and solid wedges. Valves shall be rated for 200 psi non-shock rating, manufactured by Nibco No. F-607-RW, or approved equal.
- D. Ball Valves: Ball valves, for sizes 2-inch and less, shall be two piece with a standard size port 316 stainless steel balls and stems, and reinforced seats and stuffing box rings. All ball valves shall be designed to permit repacking while valve is in line. Valves shall be furnished with blowout-proof stems. Ball valves shall be threaded ductile iron body or bronze ASTM B584 alloy 844 of a standard port design with gear operator and position indicator. Valves shall be rated for 300 psi WOG and shall conform to UL listed and FM approved, with supervisory switch, manufactured by Nibco No.KT-505-4W, or approved equal. Grooved end ball valves may be used in the sprinkler system for zone isolation for pipe sizes over 2 inches. Ductile iron body, UL listed, FM approved, standard port, TFE seats, stainless steel ball & stem, with supervisory switch, rated for 300 psi, manufactured by Victaulic Series 727, or approved equal.
- E. Butterfly Valves: For pipe sizes over 2-inch, all butterfly valves shall be full tapped and threaded lug. Manufacturer certified for bubbletight, dead end shut off from either direction at design working pressure and temperature. Valves shall have enclosed, self-locking wheel-operated worm gear type, waterproof, factory-lubricated operators and position indicators. Butterfly valves shall be 250 psig non-shock with ductile iron lug body, EPDM (EPT) replaceable seat, 316 or 416 stainless steel upper and lower stems (stems shall be positively connected to the valve disc) and EPDM (EPT) stem seals. UL listed

and FM approved, with supervisory switch, manufactured by Nibco No. LD-3510-8, or approved equal.

- F. Check Valves: Check valves 2-1/2 inch and smaller shall be UL-listed, FM-approved horizontal swing, regrinding type, renewable seat, 200lb. wwp, bronze body, threaded ends, manufactured by Nibco No. KT-403-W, or approved equal. Check valves 3 inches and larger shall be UL-listed, FM-approved flanged class 250 cast iron body (ASTM A-126 Class B), bolted bonnet, horizontal swing, renewable bronze seat and disc, manufactured by Nibco No. F-968-B, or approved equal. Grooved end check valves may be used for pipe sizes over 2-inch. UL listed and FM approved, factory tested for 500 psi, approved for services up to 250 psi, ductile iron body, spring assisted, rubber encapsulated disc, manufactured by Victaulic Series 717, or approved equal. For swing check valves, allow adequate pipe clearance to allow for proper valve operation. Provide Grinnell No. 1686 or equal ball drip where required to allow drainage at check valves.
- G. Double Check Valves: Watts Series 770-OS & Y RW, epoxy coated ductile iron valve bodies, with OS&Y gate valves with tamper switches, stainless steel internal parts, replaceable bronze seats, with bronze body ball valve test cocks.

2.4 SLEEVES AND ESCUTCHEONS

- A. Pipe passing through walls, floors, and partitions shall be provided with standard weight steel pipe sleeves. Sleeves through walls in finished spaces shall be flush. Where located in the floor construction, the sleeves shall project not less than 2 inches above the floor line. Refer to Sections 22 05 00 & 22 05 29 for fire stopping and additional sleeve requirements. Refer to drawings for details. Refer to plumbing drawings for exact locations of sleeves in structural beams. Provide escutcheons for pipes passing through walls, partitions, or ceilings. Escutcheons shall be provided where pendant sprinkler heads penetrate ceilings or sidewall heads penetrate walls. Pipe escutcheons shall be chrome-plated steel. Sprinkler escutcheons shall be white-painted or chrome-plated steel as specified. Refer to Sections 22 05 00 & 22 05 26 for additional requirements.

2.5 SLEEVES AND ESCUTCHEONS

- A. Hangers and Supports: Support fire protection pipe with UL-listed and approved hangers and support devices. Provide any special hangers or supports that may be required. The design, selection, spacing, and application of horizontal and vertical pipe hangers, supports, restraints, anchors, and guides shall be a minimum in accordance with the NFPA 13, however, all pipe hangers, rods, supports, inserts and other components shall be in accordance with specifications Section 22 05 29. All anchors shall be drilled, no shot type anchors are allowed. Refer to Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment, for pipe supports, hangers. Hanger spacing shall be according to NFPA 13

PART 3 - EXECUTION

3.1 INSTALLATION OF FIRE PROTECTION PIPING SYSTEMS

- A. General: piping system materials, components and installation shall be in accordance with NFPA 13 and as specified.
- B. Piping and joints shall be full bore reamed, for all joint types.
- C. Slag shall be removed and cleaned at all welded joints.

3.2 PIPING INSTALLATION

- A. Piping shall be concealed, except in areas without ceilings. Install all piping parallel to or at right angles to the column lines of the building wherever possible.
- B. Grade piping to eliminate traps and pockets and for drainage per NFPA 13 and NFPA 14. Where air pockets or water traps cannot be avoided, provide hose bibbs for drainage.
- C. Piping system shall be cleaned and flushed in compliance with NFPA 13 NFPA 24.
- D. Changes in direction, branches, offsets etc., shall be made with standard pipe fittings. Holes in the main for branches shall be made with a hole cutting machine and a standard "Weld-O-Let" or "Thread-O-Let" fitting used. Burning holes in the fire protection System Piping will cause that section of the piping to be cut out and replaced at the Contractor's expense.
- E. Pipe shall be reamed to full pipe diameter before joining:
 - 1. Screwed joints shall be made with standard pipe thread and an approved compound applied to the male thread only.
 - 2. Welded joints shall be made in accordance with the procedure outlined in the ANSI piping code.
 - 3. Valves and specialties shall have threaded flanged or grooved joints.
 - 4. Slag, etc. shall be removed.
- F. Install unions or flanges at equipment connections and as indicated on the Drawings.
- G. Cold-springing piping will not be permitted. Install piping with adequate support to prevent strain on the equipment and to allow for piping system expansion and contraction.
- H. Piping shall be sized as required by applicable codes and as indicated on the Drawings.
- I. Provide all test and drain lines as required by Section 8.15.2.4, Section 8.15.2.5 & Section 8.15.2.6 of NFPA 13:
 - 1. Pressure gauges, signs, and other such standard appurtenances shall be furnished as required for a complete installation in accordance with NFPA 13.
 - 2. Provide nameplate data sign at the zone controlling valve to identify the system as a hydraulically designed system indicating the location and basis for design in accordance with Section 6.7.4 and Section 24.5 of NFPA 13.
- J. Install sprinkler piping so that it can be thoroughly drained, and where practicable shall be arranged to drain at the zone drain valve. The zone drain valve shall be capable of a full discharge test without allowing water to flow onto the floor. All drips and drains shall conform to Section 8.16.2.6 of NFPA No. 13.
- K. Field changes in the piping layout or pipe sizes shall not be made without the prior approval of the Engineer.
- L. Earthwork, including trenching and backfills, shall comply with Division 31 and pipe manufacturer recommendations and per AWWA C600 and AWWA M41.
- M. Bury piping with depth of cover over top of pipe of at least 30 inches.

- N. Install underground piping with restraint joints at horizontal and vertical changes in direction. Use restraint joint piping, thrust blocks, anchors, tie-rods, clamps and other approved supports. Anchorage shall comply with NFPA 24, and AWWA C600.
- O. Gaskets joints for fire service main piping shall conform to UL 194.
- P. All underground anchor devices of ferrous material shall be fully loaded with asphalt.
- Q. Install continuous underground detectable warning tape during backfilling of trench for underground fire suppression water service piping. Refer to Division 31 for underground warning tape.
- R. Provide placards on all control valves, alarm lines, alarm test lines, floor control valves, area control valves, inspector test valves and auxiliary drain locations. Valves, etc. above ceiling or in walls shall be provided direct access and the location conspicuously noted by a permanent placard indicating the type of device and the zone it covers. Provide a zone map, mounted in an extruded metal frame with protective plexi-glass cover mounted at the sprinkler zone valve header. Map shall indicate which zone valve controls which portion of the building as well as the location of all system drain and test valves. Label each valve with lamacoid, printed signs ("Inspector's Test", "Main Drain", etc.). Map shall reflect the actual room numbers in the final approved graphics package.
- S. Provide basket type metal guards over sprinkler heads to protect them from damage in mechanical rooms, main electrical rooms, telephone equipment, storage rooms, and all unfinished areas where the head is less than 7'06" above finished floor.
- T. Stages: At each side of each stage provide a complete AHJ and NFPA compliant Class 3 standpipe system with 1-1/2" and 2-1/2" fire department hose connections. Mount hose connections in Potter Roemer lockable, clear glass front cabinet. Coordinate exact location of standpipes with stage equipment.

3.3 PIPE HANGERS AND SUPPORTS

- A. Pipe supports, sway braces, hangers, and clamps shall conform to and be placed in accordance with Chapter 9 of NFPA 13 and listed by Underwriters' Laboratories, Inc., or approved by Factory Mutual.
- B. All pipe shall be supported from the building structure in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on trapeze type hangers. Vertical risers shall be supported at each floor line with steel pipe clamps. The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes will not be permitted. Spacing of pipe supports shall not exceed 10 feet on all piping. "Shots" or any power driven hanger supports will not be acceptable.
- C. All sprinkler piping shall be adequately supported to avoid excess strain on fittings and joints. As a minimum, all vertical risers shall be supported at the bottom level, the top level and at each alternate level in between.
- D. Where pendant sprinklers are used, care shall be taken to resist upward movement of flowing sprinklers by means of rigid hangers or other restraints on the ends of branch lines or arm over exceeding 5 feet in length.

- E. Valve Stems: Install valves with stems pointed up, in the vertical position where possible, but in no case with stems pointed downward from a horizontal plane. All valves shall be located so as to make the removal of their bonnets possible. All flanged valves shown in the horizontal lines with the valve stem in a horizontal position shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be made up with their valve stems inclined at an angle of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested for final acceptance. Valves shall be installed as nearly as possible in the locations as shown on and Drawings. Any change in valve location must be so indicated on the As-built Drawings.
- F. Valve Chain Operators: In mechanical rooms where valves are installed over 8 feet above floor, provide chain operators.
- G. Unions and Companion Flanges: Provide unions or companion flanges where required to facilitate dismantling of valves and equipment.
- H. Gauges: Provide gauges as required by NFPA 13: On the suction side and discharge side of each fire and jockey pump, and at fire service water entry.

3.4 CLEANING AND STERILIZATION

- A. All fire protection piping shall be thoroughly flushed out, to remove any slag or debris prior to being tested or put into service. Comply with NFPA standards and guidelines. Underground piping extending from the water supply to the system riser and lead-in connections to the system riser shall be completely flushed before connection is made to downstream fire protection system piping. The flushing operation shall be continued for a sufficient time, as determined by Owner or Architect/Engineer to ensure thorough cleaning. The minimum rate of flow shall not be less than a flow necessary to provide a velocity of 10 feet per second in accordance with in NFPA 13 or hydraulically calculated water demand rate of the system, including fire hose requirements. Provisions shall be provided for proper disposal of water used for tested and flushing. Refer to NFPA 13 Section 8.16.3, Section 10.10.2.1 and Section A.10.10.2.1 for methods of flushing water supply connections. Owner shall be provided in writing the flushing procedure and shall witness and approve flushing of system prior to continuation of work. Flush piping system without sprinkler heads installed. Contractor is responsible for providing any pump required for flushing system at the specified velocity. Flush piping system at the ends of the cross mains. Individual sprinkler heads shall not be installed during flushing. The individual supply lines to each sprinkler head shall be capped during the flushing procedure. After the piping system has been flushed. The individual capped lines shall be drained and any debris, slag, etc. removed. The sprinkler heads shall then be installed once the system has been approved as successfully cleaned and flushed.

3.5 BUILDING FIRE ALARM SYSTEM INTERFACE

- A. Each device, such as supervision switches, fire pump operation, flow switches, etc. shall provide an alarm signal output to the Building Fire Alarm System (wiring by Division 26). Each valve which controls the flow of sprinkler system water shall be monitored by the Building Fire Alarm System, unless otherwise noted.

3.6 TESTS AND INSPECTIONS

- A. Inspections, examinations and tests required by the authorities or agencies specified shall be arranged and paid for by the Fire Protection Subcontractor, as necessary, to obtain complete and final acceptance of the system as installed. The certificates of

inspection shall be in quadruplicate, and shall be delivered to the Engineer for review and distribution.

- B. Fire protection piping systems shall be hydrostatically tested by the Contractor upon completion of the installation as required by Section 10.10.2.2 of NFPA 13 in the presence of the Owners Representative.
 - 1. The fire protection piping systems shall be hydrostatically tested at 200 psi for 2 hours without loss of pressure.
 - 2. When hydrostatic and alarm tests have been completed and all necessary corrections made, a material and test certification shall be provided in accordance with Section 10.10 of NFPA 13.
 - 3. Final inspection shall include full flow testing through the inspectors test connection.
 - 4. Actuation of the flow switch shall occur within one minute of opening of the inspector's test valve.
 - 5. Final tests may be witnessed by the Engineer or Owner's Representative.
- C. Sprinkler system zone control assemblies shall be tested to demonstrate proper operation of the flow switch and valve supervisory switch.
- D. Arrange and pay for all tests and inspections required by authorities having jurisdiction.
- E. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Testing of complete sprinkler system for acceptance shall be witnessed by an Owner's Representative. Testing shall be coordinated with the Authority Having Jurisdiction.

3.7 PERIODIC INSPECTION SERVICE

- A. After completion of the fire protection system installation and at the beginning of the guarantee period, the Automatic Sprinkler Subcontractor shall execute the National Automatic Sprinkler and Fire Control Association, Inc., Standard Form of "Inspection Agreement", without change in the Contract amount, calling for four inspections of the fire protection system during the warranty period.
- B. During the warranty period, inspections shall be in accordance with the Inspection Agreement, plus the following maintenance to be performed during the course of the fourth inspection:
 - 1. Operation of all control valves.
 - 2. Lubrication of operating stems of all interior valves.
 - 3. Operation of all alarms, supervisory switches, air compressors, alarm trip switches, flow switches, and similar items.
 - 4. Cleaning of alarm valves.
 - 5. Lubrication of Fire Department valve hose connections.
 - 6. The standard form of the National Automatic Sprinkler and Fire Control Association, Inc., "Report of Inspection", shall be filled out in triplicate after each inspection and the copies sent to the Architect.

3.8 IDENTIFICATION

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

- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53, Electrical Identification.

3.9 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.

END OF SECTION

SECTION 21 13 13

AUTOMATIC SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes labor and materials for the installation of a hydraulically calculated automatic, wet-pipe sprinkler system(s) and dry pipe sprinkler systems in areas as specified, and as shown on the Drawings, complete in all respects and ready for operation.
 - 1. Work includes the design of a wet-pipe automatic sprinkler system, complete and ready for operation.
 - 2. Design and installation of the sprinkler system shall be such that no parts interfere with general construction, doors, windows, heating, plumbing, air conditioning systems or electrical equipment.
- B. System components for each zone shall include, but not be limited to:
 - 1. Zone control valve and test/drain assembly.
 - 2. Drain valve.
 - 3. Waterflow switches.
 - 4. Valve supervisory switches.
 - 5. Piping.
 - 6. Sprinkler heads.

1.2 SYSTEM DESCRIPTION

- A. The sprinkler systems shall be fixed water type fire protection sprinkler system with a pressurized water supply to fusible sprinkler heads for control of fire.
- B. The sprinkler system shall be designed to meet the more stringent of the requirements of NFPA 13.
- C. All sprinkler heads in general shall be in a straight line, parallel to the lines of the building and shall be located in the approximate center of ceiling tiles.
 - 1. Sprinkler head quantities, where shown, are the minimum, which must be provided. If additional heads are required to meet NFPA 13, the location of additional heads must be approved by the Architect.
 - 2. Contractor shall submit Sprinkler Head locations to the Architect for location and type approval prior to completing the sprinkler system design, unless otherwise instructed, in writing, by the Architect.
- D. Work shall be installed in accordance with the Drawings, Specifications. Devices and equipment shall be listed by Underwriters' Laboratories, Inc. or Factory Mutual-approved, individually and as a system, as applicable.
- E. Sprinkler heads shall be spaced, located, and positioned as shown on the Architectural reflected ceiling plans, where shown, as specified and as required to suit the building partition layout according to Sections 8.5 and Section 8.6 of NFPA 13.

- F. Piping sizes and configurations shall be on the basis of hydraulic calculations. Where head layouts shown on the Drawings or requirements specified are more stringent than NFPA requirements, the more stringent requirements shall apply.
- G. Zone the sprinkler system with a maximum 52,000 sq. ft. area limitation per zone.
- H. Coordinate the location of sprinkler heads and piping such that it does not interfere with the installed ceiling configuration or other building construction and equipment.

1.3 HYDRAULIC CALCULATIONS

- A. Prepare hydraulic calculations in accordance with Chapter 14 of NFPA 13 with the following exceptions:
 - 1. Pipe friction losses may be calculated by using the nearest foot for all piping over one foot in length. Vertical length less than one foot shall be included for elevation purposes only.
 - 2. Calculate flows to the nearest whole gallon.
 - 3. Total sprinkler system flow shall not exceed 110 percent of the required flow.
 - 4. Provide a minimum safety factor of 10 percent on all hydraulically calculated sprinkler systems.
- B. Sprinkler system hydraulic calculations shall be based on the following:
 - 1. Public Spaces, Offices, Conference Rooms, Learning Centers, Entries, Hallways and Similar Areas -- Light Hazard Occupancy with design density of 0.10 gpm over the most remote 1500 square foot, with a maximum coverage area, per head, of 225 square foot.
 - 2. Mechanical Rooms, Gym, Storage Rooms, Janitor Rooms, Service Areas, Laboratory Areas, Prep Rooms and Electrical Rooms -- Ordinary Hazard Group 1 with a design density of 0.15 gpm over the most remote 1500 square foot with a maximum head coverage of 130 square foot.
 - 3. Provide 250 gpm hose steam allowance.
 - 4. Maximum spacing between heads of 15-foot on center, unless extended coverage type heads are used.
- C. Hydraulic calculations shall be performed by a State of Texas Licensed Responsible Managing Employee (RME) in the direct employ of the fire protection contractor.
- D. Hydraulic Calculations shall be based on flow test conducted by this contractor or recent flow test information provided from the City of Houston performed by MLN Fire Protection Company, dated 10/1/2015. The flow test was performed on a fire hydrants along Stancliff Street at Flow Hydrant #1 (#3792371) north of Heatherbloom Street at Gauge Hydrant #2 (#3793082) south of Heatherbrook Street. The results are as follows: 80 psi static, 78 psi residual at 1201 gpm flow rate.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Provide total hydraulically designed sprinkler system with plans, elevations, sections, details, and related attachments including Wiring Diagrams for power, signal, and control wiring.
- C. All submittals shall be provided to Owner and A/E for review and approval prior to any work.

- D. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- E. Qualification Data: For qualified Installer and Professional Engineer.
- F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- G. Welding certificates.
- H. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- I. Field quality-control reports.
- J. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."
 - 2. NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height."
 - 3. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

PART 2 - PRODUCTS

2.1 SPRINKLERS

- A. Manufacturers: Design of Sprinkler heads is based on model numbers manufactured by Viking Corporation unless otherwise indicated. Subject to compliance with requirements, provide named product or approved equivalent.
- B. Unless otherwise specified, sprinkler heads shall be a quick response type with standard (155°F) temperature rated fusible link, 1/2 inch orifice and a 5.6 K factor.

1. Heads located within the air streams of heat emitting equipment, Gas Fired water heater Rooms, and in the Gym (High Bay Areas) and similar areas shall have an intermediate (200°F) temperature rated fusible link.
 2. Install corrosion-resistant sprinkler heads where they are exposed to weather, moisture, or corrosive vapors.
 3. Heads installed where they might receive mechanical injury, such as in gym type areas or in areas where heads are less than 7 feet above the floor level shall be protected with approved guards in accordance with Section 6.2.8 of NFPA 13.
 4. Sprinklers in areas with suspended ceilings shall have pipe and fittings located above the suspended ceiling.
 5. Sprinkler heads in finished areas, with ceilings, shall be Quick Response semi-recessed type sprinkler head, manufactured by Victaulic Model V2708 or approved equivalent. Where specifically indicated on drawings to use concealed heads, the heads shall have white finish.
- C. Sprinkler heads in unfinished areas shall be Quick Response upright or sidewall with brass finish, manufactured by Victaulic Model D2710 sidewall and Victaulic V2704 upright or approved equivalent.
- D. Provide recessed type dry type sprinkler head with white finish and escutcheon, to protect freezers, manufactured by Victaulic Model V36 dry pendant or approved equal
- E. Sprinkler heads shall be UL Listed and FM approved.
- F. Provide metal cabinet containing a stock of spare sprinkler heads of all types and ratings installed.
1. Locate cabinet where temperature will not exceed 100 °F.
 2. Location shall be approved by the Owner.
 3. Number of spare sprinklers shall conform to Section 6.2.9 of NFPA 13.
 4. Provide a sprinkler wrench in the cabinet, for each different type sprinkler head.
- G. The use of extended coverage heads is acceptable.
- H. The use of UL listed and FM approved flexible type head assemblies is permitted. Flex type head assembly shall consist of 304 stainless steel braided hose with zinc plated steel 1" NPT male threaded nipple, factory tested at 400 psi, complete with one piece head securing bracket assembly, tamper resistant screws, The drop shall include a UL approved Series AH2 braided hose with a bend radius to 2" to allow for proper installation in confined spaces. The hose shall be listed for [(4) bends at 31" length] [(5) bends at 36" length] [(8) bends at 48" length] [(10) bends at 60" length] [(12) bends at 72" length]. Manufactured by Victaulic "Aquaflex".
- I. Sprinklers with o-rings are not acceptable.
- 2.2 VALVE SUPERVISORY SWITCHES
- A. Contractor shall furnish and install supervisory switches. Coordinate wiring of switches with Division 26 Electrical Sections.

2.3 WATERFLOW SWITCHES

- A. Provide Viking VSR-F or equivalent waterflow switches, with adjustable retard feature in the supply pipe to each zone for remote alarm. Switch shall be double-pole single-throw type and shall be rated at least 7 amperes at 125/250 volts.
- B. Waterflow pressure switches shall be furnished and installed by this Contractor and wired under provisions of Division 26 Electrical Sections. Coordinate wiring of flow switches with Division 26 Electrical Sections.

2.4 BUILDING FIRE ALARM SYSTEM INTERFACE

- A. Each zone control assembly shall provide an alarm signal output to the Building Fire Alarm System whenever there is waterflow in the zone. Coordinate with Division 28 Electronic Safety and Security Sections.
- B. Each valve which controls the flow of sprinkler system water shall be monitored by the Building Fire Alarm System. Coordinate with Division 28 Electronic Safety and Security Sections.

2.5 PIPE, VALVES AND FITTINGS

- A. Refer to Section 21 13 00.

2.6 SPRINKLER SYSTEM INSPECTOR'S TEST ASSEMBLY

- A. Provide NFPA 13 compliant UL Listed and FM approved sprinkler system inspector's test assembly, consisting of sight glass, tamper resistant test orifice, test and drain ball valve, rated for 300 psi, size indicated on the plumbing plans, manufactured by AGF Model 1000, or approved equal

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.
- C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

- D. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler control valves, test assemblies, and drain risers where indicated on the fire protection drawings.
- I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building, as indicated on drawings.
- J. Install alarm devices in piping systems.
- K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- L. Install pressure gages on riser or feed main, at each sprinkler test connection. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- M. Fill sprinkler system piping with water.
- N. In areas with wood ceilings, provide sprinkler heads in the ceiling and above the ceiling in compliance with NFPA 13.
- O. Sprinklers in suspended ceilings shall be provided with arm over supply line. Refer to detail on fire protection drawings.
- P. The only sprinkler piping allowed in Electrical Rooms is the sprinkler piping which serves the sprinkler heads in that room.

3.2 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes full bore and remove burrs. Bevel plain ends of steel pipe.

- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- I. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to paragraph 1.5, "Quality Assurance".
 - 1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- J. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- K. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- L. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- M. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.3 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Specialty Valves:
 - 1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 - 2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

3.4 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.
- B. For installation of flex head assemblies follow flex sprinkler assembly manufacturer recommendations. Flex head assemblies shall not connect to cross mains from the bottom of the pipe, only from the side or top.
- C. Install automatic (ball drip) drain valve at each check valve for fire-department connection.
- D. Coordinate the location of sprinkler system piping around all other trades, such as HVAC, plumbing and electrical, prior to installation.
- E. In exposed areas with ductwork 48" and wider, provide sprinkler heads both above and below ductwork as outlined in NFPA 13.
- F. Provide sprinkler heads both above and in ceilings constructed of wood, as required by NFPA 13.
- G. Provide sprinkler heads 2'-0" from the bottom of the elevator shafts as required by NFPA 13.
- H. Provide sprinkler head guards on sprinkler heads in gym areas.

3.5 ESCUTCHEON INSTALLATION

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

3.6 SLEEVE INSTALLATION

- A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
- B. Sleeves are not required for core-drilled holes.
- C. Permanent sleeves are not required for holes formed by removable PE sleeves.
- D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
- E. Install sleeves in new partitions, slabs, and walls as they are built.
- F. For wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section, Joint Sealants.
- G. Seal space outside of sleeves in concrete slabs and walls with grout.
- H. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Division 07 Section, Penetration Firestopping.

3.7 SLEEVE SEAL INSTALLATION

- A. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.8 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53, Electrical Identification.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Start and run excess-pressure pumps.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Verify that equipment hose threads are same as local fire-department equipment.
 - 8. Sprinkler system zone control assemblies shall be tested to demonstrate proper operation of the flow switch and valve supervisory switch.
 - 9. Arrange & pay for all tests and inspections required by authorities having jurisdiction.
- C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.

END OF SECTION

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SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the common work results requirements for Division 22, Plumbing. Applicable provisions of this Section apply to all Sections of Division 22.

1.2 GENERAL

- A. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements and provide coordination drawings.
- B. Prior to starting work, Contractor shall provide 1/4 inch scale coordination drawings for all areas of the buildings for approval by Architect/Engineer.
 - 1. Drawings shall show all equipment, piping, ductwork, cable trays, fire protection systems, coil pull spaces, chilled water, heating water, and condensate piping and trap, electrical conduit, electrical control panels, etc. installed to verify space allocation and coordination of trades.
 - 2. Provide plan and elevation views detailing installation.
 - 3. Do not proceed with construction of plumbing systems until Drawings have been approved by Architect, Engineer, and Owner.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than plumbing and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and plumbing equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 CODE REQUIREMENTS AND PERMITS

- A. Perform work in accordance with applicable statutes, guidelines, ordinances, codes, and regulations of governmental authorities and owners having jurisdiction.
- B. Resolve code violations discovered in contract documents with Engineer prior to award of Contract. After award of Contract, make correction or addition necessary for compliance with applicable codes at no additional cost to Owner.

- C. Obtain and pay for all permits and inspections.

1.5 SUBMITTALS

- A. Material and Equipment List: Within 30 days after award of the contract and before orders are placed or shop drawings are submitted, submit a list of equipment and principal materials specified. Give names of manufacturers, catalog and model numbers, and such other supplementary information as necessary for identification.
- B. Material and Equipment Shop Drawings: Submit all detailed shop drawings, descriptive literature, physical data, and performance data at one time for review for items of equipment and for principal materials proposed for installation. Include identifying symbols and equipment numbers used in plans and specifications, with reference to specification paragraphs, and drawing numbers of all equipment and material submitted.
- C. Final Submittal: In addition to number of copies of shop drawings and other data required for review submittals, maintain a separate file of final approved copies of such material. Deliver approved copies in a hard-back binder for the Owner's use. Incorporate changes and revisions made throughout construction period. Delivery of approved copies is a condition of final acceptance for the project.
- D. Contractor's Check: Shop drawings will be submitted only by the Contractor. Indicate by signed stamp that the drawings have been checked, that the work shown on the drawings is in accordance with contract requirements and that dimensions and relationship with work of other trades have been checked. If drawings are submitted for approval that have not been checked and signed by the Contractor, they will be returned for checking before being considered by the Architect/Engineer.

1.6 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. The Contractor shall furnish five copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings. Detailed requirements for these items are as follows:
 - 1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies to the equipment and information which does not apply. Data shall include as a minimum the following items:
 - a. Recommended procedures and frequencies for preventive maintenance, inspection, adjustment, lubrication, cleaning, etc.
 - b. Special tools and equipment required for testing and maintenance.
 - c. Parts lists reflecting the true manufacturer's name, part number, and nomenclature.
 - d. Recommended spares by part number and nomenclature and spare stocking levels.
 - e. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
 - f. Troubleshooting, checkout, repair, and replacement procurement procedures.
 - g. Operating instructions including start-up and shutdown procedures.
 - h. Safety considerations including load limits, speed, temperature, and pressure.
- B. Provide O&M manuals for all plumbing equipment. Coordinate O&M manuals with Division 01.

- C. Upon completion of work, and at time designated by the Architect/Engineer, provide services of a competent representative of the Contractor for a period of at least 40 hours to instruct the Owner's Representative in the operation and maintenance of the entire system.

1.7 PROJECT RECORD DOCUMENTS

- A. Preparation:
 - 1. Maintain at the job site a separate set of white prints of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is significantly at variance with the contract drawings.
 - 2. Mark the drawings with a colored pencil.
 - 3. Prepare, as the work progresses and upon completion of work, drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed
 - 4. Include flow-line elevation of sewer lines.
 - 5. Record underground and underslab piping installed, dimensioning exact location and elevation of such piping.
 - 6. Coordinate requirements for Project Record Documents with Division 01.
- B. Deliver: At conclusion of project, obtain without cost to Owner, reproducibles of original mechanical drawings and transfer as-built changes to these. Delivery of as-built prints and reproducibles is a condition of final acceptance.

1.8 GUARANTEE

- A. Guarantee work for 1 year from the date of final acceptance of the project, and during that period make good any faults or imperfections that may arise due to defects or omissions in materials or workmanship. Coordinate requirements for Warranty with Division 01.

1.9 SERVICE

- A. Perform service work required during the guarantee period including lubrication of bearings. Perform service monthly, and provide the Owner with a written report. Cleaning of air filters and pipe strainers is not included.

1.10 REFERENCE SPECIFICATIONS AND STANDARDS

- A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions (except where specified otherwise in individual sections), revisions, amendments or supplements in effect on date bids are received.
 - 1. Requirements in reference specifications and standards are minimum for all equipment, material and work.
 - 2. In instances where capacities, size or other feature of equipment, devices or materials exceed these minimums, meet listed or shown capacities.

1.11 CUTTING AND PATCHING

- A. General: Cut and patch walls, floors, etc., resulting from work or by failure to provide proper openings or recesses in new construction.

- B. Methods of Cutting:
 - 1. Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer.
 - 2. Impact-type equipment shall not be used except where specifically acceptable to the Architect/Engineer.
 - 3. Openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., shall be core drilled to exact size.
- C. Restoration:
 - 1. All openings shall be restored to "as-new" condition under the appropriate Specification Section for the materials involved, and shall match remaining surrounding materials and/or finishes.
- D. Masonry:
 - 1. Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry.
 - 2. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation.
 - 3. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.
- E. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

1.12 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Furnish new and unused materials, pipes, pipe fittings, and equipment of domestic manufacturer where available. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

2.2 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are listed in individual Sections of Division 22. Manufacturer's names and catalog numbers specified under Sections of Division 22 are used to establish standards of design, performance, quality and serviceability and not to limit competition.

Equipment of similar design, equal to that specified, manufactured by a manufacturer named in the acceptable manufacturer's list will be accepted upon approval.

B. Substitutions:

1. If the Contractor desires to substitute a material or method as an equal to the specified item, he shall request permission from the Architect/Engineer, in writing, and shall include such literature, samples, etc., deemed necessary to establish the equal quality of his proposal.
2. If the Architect/Engineer deems it necessary in order to establish the equality between two or more products, he may require laboratory testing at the Contractor's expense in order to obtain information upon which to base a decision.
3. The Architect/Engineer will not give approval to material salesmen or subcontractors and only in writing to the successful Contractor after the project has been awarded.
4. For each proposed substitution product, clearly show how the proposed product meets the requirements of the specifications, including performance.
5. No substitution will be considered unless it is presented in writing within that number of days after Notice to Proceed equal to 15 percent of the contract time.
6. Proposers of substitute products shall present samples, literature, test and performance data, record of other installations, names of Owners, architects, engineers, contractors and subcontractors as references, statement of current financial condition, and other technical information applicable to their products, to aid in determining the worth of the substitute product offered in relation to the material and work specified from the standpoint of the Owner's best interest.
7. Substitute materials and products shall be used only if approved in writing by the Architect/Engineer in advance.
8. Approval of substitute materials offered shall not be a basis for contingent extra charges because of changes in other work or related work, such as roughing-in, electrical, structural, or architectural, which may result from the substitution.
9. For any Contractor initiated substitutions or changes, Contractor shall be responsible for achieving results equal to or better than the product or design originally specified.

2.3 PIPE STRAINERS

- A. Immediately prior to final acceptance of project, inspect, clean and service piping system strainers.
- B. Turn over to Owner additional sets of spare parts as specified.

2.4 FLAME SPREAD PROPERTIES OF MATERIALS

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50.

2.5 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.6 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8" Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.
- E. Welding Filler Metals: Comply with AWS D10.12.
- F. Solvent Cements for Joining Plastic Piping:
 - 1. ABS Piping: ASTM D 2235.
 - 2. CPVC Piping: ASTM F 493.
 - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 4. PVC to ABS Piping Transition: ASTM D 3138.

2.7 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180°F.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.
- F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225°F.

2.8 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
- B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
- C. Pressure Plates: Stainless steel. Include two for each sealing element.
- D. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

- A. Through Floors: Galvanized schedule 40 steel pipe sleeve with water ring, as detailed.
- B. Through Walls in Crawl Space: Galvanized schedule 40 steel pipe sleeve with water ring, as detailed.
- C. Sleeves Through Interior Walls: 22 gauge galvanized steel snap lock. No screws through vapor barrier.

2.10 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.

2.11 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors.
- M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 - 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section, Penetration Firestopping, for materials.
- P. Verify final equipment locations for roughing-in.
- Q. Refer to equipment specifications in other Sections for roughing-in requirements.
- R. Provide fire rated type access panels in fire rated walls where indicated in drawings. Access panel to match or exceed to wall rating.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.3 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

- C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.5 OBSTRUCTIONS

- A. Drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
- B. Before any cutting or trenching operations are begun, verify with Owner's Representative, utility companies and other interested parties that all available information has been provided. Verify locations given.
- C. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.
- D. Assume total responsibility for and repair any damage to existing utilities or construction.

3.6 OPENINGS

- A. Framed, cast or masonry openings for ductwork, equipment and piping are specified under other divisions. However, drawings and layout work for exact size and location of all such openings are included under this division.

3.7 PROTECTION

- A. Adequately protect work, equipment, fixtures and materials from damage during storing, installation, start-up and testing.
- B. Cover all equipment stored exposed to elements with waterproof tarps. Provide adequate ventilation. At work completion, all work must be clean and in like new condition.
- C. Storage of all mechanical equipment and piping materials shall be in strict accordance with manufacturers written installation instructions.
- D. Provide factory installed pipe caps for all pipes to be installed on the project.

3.8 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section, Cast-in-Place Concrete.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section, Metal Fabrications, for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.11 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

3.12 TEMPORARY CONDITIONING OF BUILDING SPACES FOR COMPLETION OF CONSTRUCTION

- A. All equipment utilized will be checked out by a factory representative, serviced, lubricated, checked for rotation, pressure, amp draw and vibration isolation, adjusted and certified. Record of this service must be provided monthly to the Owner. Submit appropriate reports to the University prior to submitting a written request for service.

- B. All equipment operated shall be serviced on a regular basis by the Contractor.
- C. Prior to final inspection, clean all equipment inside and out to a like new condition, remove temporary filters, install new permanent filters in preparation for final inspection by Owner.
- D. All warranties will be commenced at the time of final acceptance.

3.13 OPERATING TESTS

- A. After all plumbing systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation witnessed by Owner's Representative.
- B. Prove operations of control systems and all safeties, and alarms. Make adjustments as required to ensure proper functioning of all systems. Special tests on individual systems are specified under individual Sections.
- C. Functional Performance Testing is part of the Commissioning Process. Functional performance testing shall be performed by the Contractor and witnessed and documented by the Commissioning Agent. Refer to Section 019113, General Commissioning, for functional performance testing and commissioning requirements.

3.14 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. The Contractor shall furnish five copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings. Detailed requirements for these items are as follows:
 - 1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies to the equipment and information which does not apply. Data shall include as a minimum the following items:
 - 2. Recommended procedures and frequencies for preventive maintenance; inspection, adjustment, lubrication, cleaning, etc.
 - 3. Special tools and equipment required for testing and maintenance.
 - 4. Parts lists reflecting the true manufacturer's name, part number and nomenclature.
 - 5. Recommended spares by part number and nomenclature and spare stocking levels.
 - 6. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
 - 7. Troubleshooting, checkout, repair and replacement procurement procedures.
 - 8. Operating instructions including start up and shutdown procedures.
 - 9. Safety considerations including load limits, speed, temperature and pressure.
 - 10. Provide O&M manuals for all plumbing equipment. Coordinate requirements for O&M Manuals with Division 01.

3.15 OPERATING INSTRUCTIONS

- A. Upon completion of work, and at time designated by the Owner's Representative, provide services of a competent representative of the Contractor for a period of at least 40 hours to instruct the Owner's Representative in the operation and maintenance of the entire system. The training sessions will be video taped for instructing future technicians.

- B. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans. Refer to Section 019113, General Commissioning, for contractor training requirements.

- C. Coordinate requirements for training with Division 01.

END OF SECTION

SECTION 22 05 26

PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for pipe and pipe fittings for all piping systems. This Section applies to all Plumbing Sections of Division 22 which employ pipe and pipe fittings. Fabricate and erect all piping in accordance with ASME/ANSI B31.9 except as otherwise indicated.

1.2 RELATED SECTIONS

- A. Division 07 – Thermal and moisture protection for firestopping requirements.
- B. Division 09 – Finishes for painting requirements.
- C. Section 22 05 00 – Common Work Results for Plumbing
- D. Section 22 05 53 - Identification for Plumbing Piping and Equipment.
- E. Section 22 11 16 - Domestic Water Piping Systems.
- F. Section 22 13 19 – Sanitary Waste and Vent Piping.

1.3 SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 paragraphs where titles below introduce lists or manufacturers, the following requirements apply to product selection:
 - 1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the manufacturer specified.

2.2 PIPE AND FITTINGS

- A. The particular type of pipe and fittings for each system is specified in the Section for that system. All piping and fittings shall be of U.S. Manufacturer. All pipe shall be shipped capped. Shipped and store on job site with ends capped from the factory.

2.3 JOINTS

- A. Screwed: Make screwed joints using machine-cut ANSI taper pipe threads. Apply a suitable joint compound, such as Teflon tape, to the male threads only. Ream the pipe to full inside diameter after cutting. All-thread nipples are not permitted.
- B. Dissimilar Metals: Make joints between copper and steel pipe and equipment along with steel pipe and ductile iron pipe using insulating unions such as Crane Company No. 1259; EPCO as manufactured by EPCO Sales, Inc.; or an approved equal.
- C. Solder Joints:
 - 1. Prior to making joints, cut pipe square and ream to full diameter. Clean exterior of pipe and socket. Apply a thin coat of suitable fluxing compound to both pipe and socket, and fit parts together immediately.
 - 2. Heat assembled joint only as required to cause the solder to flow. Run the joint full, slightly beaded on the outside, and wipe to remove excess solder.
 - 3. Utilize lead free solder. Use silver brazing alloy or Sil-Fos on refrigerant piping and on underground piping.
- D. Welded Joints:
 - 1. Make welded joints as recommended by the standards of the American Welding Society.
 - 2. Ensure complete penetration of deposited metal with base metal.
 - 3. Provide filler metal suitable for use with base metal.
 - 4. Keep inside of fittings free from globules of weld metal.
 - 5. Do not use mitered joints.
 - 6. Use standard weld elbow fittings for changes of direction or cut a standard elbow for odd angles.
- E. Flanged Joints:
 - 1. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe and equipment. Align bolt holes to straddle the vertical, horizontal or north-south centerline. Do not exceed 3/64 inch per foot inclination of the flange face from true alignment.
 - 2. Use flat-face companion flanges only with flat-faced fittings, valves or equipment. Otherwise, use raised-face flanges.
 - 3. Install proper gaskets, suitable for intended service and factory cut to proper dimensions. Red rubber gaskets are not acceptable. Garlock gaskets or EPDM shall be used. Apply non-stick clean surface lubricant coating to both sides of gaskets.
 - 4. Use ANSI nuts and bolts, galvanized or black to match flange material. Use Coreten or galvanized steel nuts and bolts underground. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets. Use anti-seize compound on all bolts above and below grade. Bolt threads not to protrude more than 2 threads past nut.
 - 5. Use carbon steel flanges conforming to ANSI B16.5 with materials conforming to ASTM A 105, Grade II or ASTM A 108, Grade II. Use welding neck type flanges at all fittings and on all pipe.
 - 6. Flanges for ductile iron pipe are specified in Sections using that pipe.
 - 7. Keep flange covers on equipment and shop-fabricated piping until ready to install in system.
- F. No Hub: Install according to manufacturer's recommendations, using recommended tools.

- G. Bell and Spigot: Use neoprene compression gaskets for sanitary and storm.
- H. Push-on Joints (Ductile Iron Pipe): Restrained joints and gaskets for ductile iron pipe are specified in Sections using that pipe.

2.4 UNIONS

- A. Use 150-pound standard (300-pound WOG) malleable iron, ground joint unions with bronze seat. Provide flanged union joints on piping larger than 2-1/2 inches.

2.5 BRANCH CONNECTIONS

- A. For Pipe 2 inches and smaller, use threaded fittings for steel pipe. For threaded piping, use straight size of reducing tee.
- B. For 2-1/2 Inches through 14 Inches: For welded piping, when branch size is the same as and one size smaller than header size, use welding tee. Use Weld-O-Let when branch is two or more sizes smaller than header. For threaded branch connections, use thread-o-let welded to header.
- C. All changes in direction, branches, offsets etc., shall be made with standard pipe fittings. Holes in the main for branches shall be made with a hole cutting machine and a standard "Weld-O-Let" or "Thread-O-Let" fitting used. Burning holes in the system piping will cause that section of the piping to be cut out and replaced at the Contractor's expense

2.6 GASKETS

- A. Provide gaskets between flanges of all flanged joints. Inside diameter of gaskets shall conform to nominal pipe size. Gaskets shall be ring type between raised face flanges and full face between flat face flanges with punched bolt holes and pipe opening.
- B. Gaskets shall be cut from 1/8 inch thick non-metallic, non-asbestos gasket material suitable for operating temperatures from -150°F to +750°F. Garlock or equal. For pipe smaller than 6 inches, use 1/16-inch-thick gasket.

2.7 FLOOR AND CEILING PLATES

- A. Provide chrome-plated floor and ceiling plates around pipes exposed to view and passing through walls, floors, partitions, or ceilings in finished areas. Size plates to fit pipe or insulation and securely lock in place.

PART 3 - EXECUTION

3.1 PIPE FABRICATION AND INSTALLATION

- A. Make piping layout and installation in the most advantageous manner possible with respect to headroom, valve access, opening and equipment clearance, and clearance for other work.
- B. Give particular attention to piping in the vicinity of equipment. Preserve the maximum access to various equipment parts for maintenance. Install piping plumb and parallel with building walls.

- C. Do not cut or weaken any structural member.
- D. Cut all pipes accurately to measurement determined at the site. After cutting pipe, ream it to remove burrs.
- E. Install piping neatly, free from unnecessary traps and pockets. Work into place without springing or forcing. Use fittings to make all changes in direction. Field bending and mitering are prohibited. Make all connections to equipment using flanged joints or unions. Make reducing connections with reducing fittings only.
- F. All water piping installed above ground or below ground and in trenches, must be installed by a licensed Plumbing Contractor at building rates. The wage rates for building trades apply only to the extent of work required to be installed by licensed Plumbing Contractors.

3.2 WELDING

- A. Weld and fabricate piping in accordance with ANSI Standard B31.9, latest edition, Code for Pressure Piping. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.
- B. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.
- C. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
- D. Do not split, bend, flatten or otherwise damage piping before, during or after installation.
- E. Remove dirt, scale, and other foreign matter from inside piping before tying in sections, fittings, valves or equipment.

3.3 OFFSETS AND FITTINGS

- A. Because of the small scale of Drawings, the indication of all offsets and fittings is not possible. Carefully investigate the structural and finish conditions affecting the work and take such steps as may be required to meet such conditions.
- B. Install all piping close to walls, ceilings, and columns so piping will occupy the minimum space. Provide proper space for covering and removal of pipe, special clearances, and for offsets and fittings.

3.4 PIPE SLEEVES

- A. Fit with sleeves all pipes passing through gyp board, masonry, and concrete construction, refer to specification section 22 05 00 and the following:
 - 1. Provide 22 gauge wall sleeves for pipes passing through gyp board walls.
 - 2. Fabricate floor sleeves of schedule 40 weight galvanized steel pipe and masonry wall sleeves of 40 gauge galvanized steel.
 - 3. Size sleeve for minimum clearance between pipe or insulation and sleeve.
 - 4. All sleeves in wet lab areas to have a welded waterstop.
 - 5. All sleeves shall be hot dipped galvanized after fabrication.

- B. Extend each sleeve through the floor or wall. Cut the sleeve flush with each surface, except that in exposed locations, extend floor sleeves 2 inches above finished floor line.
- C. Seal all sleeves water and airtight. Seal annular space between pipes and sleeves with compound with flame and smoke spread rating of minimum 25/50 in accordance with ASTM E 84 test.
- D. Sleeves below grades in outside walls are detailed on drawings. Except as shown otherwise, provide Thunderline Link-Seal or approved equivalent with stainless steel nuts and bolts, with cast iron pressure plate.

3.5 ISOLATION VALVES

- A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving all equipment, and at other locations as indicated and required for isolation of piping or equipment.

3.6 DRAIN VALVES AND VENTS

- A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained. Install a 2 inch drain for 2-inch pipes and larger. Install a line size drain valve for pipes smaller than 2 inches. Provide hose adapter and cap on all drain lines.
- B. Provide automatic vents with isolation valves or manual vents at locations as indicated on drawings and all high points in piping systems.

3.7 CLEANING OF PIPING SYSTEMS

- A. Cleaning of piping system must be performed by an independent agency specializing in this type of work:
 - 1. The agency must have a minimum of 5 years experience with at least three projects of similar size.
 - 2. Submit project names for review.
- B. Minimum velocity of 10 feet per second must be maintained in the pipes during flushing period:
 - 1. Do not use building pumps for circulating water.
 - 2. Provide temporary pumps as required to achieve minimum velocities.
 - 3. Remove flow meters from building piping during flushing operation.
 - 4. Provide means (instrumentation) during flushing period to prove to the Owner that the minimum velocities are maintained in the pipes.
- C. Submit a detailed plan for the Engineer's and Owner's review and approval describing in full detail the individual steps associated with this process before any piping is installed:
 - 1. Plan must include a drawing indicating GPM's required to provide minimum velocity required in the piping, phasing of systems being cleaned, locations of drains or other temporary connections required for cleaning system, and cutsheet of temporary pump proposed.
- D. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide temporary connections and valves as required for cleaning, purging and circulating.

- E. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blowoff valve.
- F. Domestic Water Piping:
 - 1. All potable water piping and tanks shall, after successful pressure testing, be thoroughly flushed with clear water and then sterilized.
 - 2. Sterilization shall be with either liquid chlorine or chlorine gas of adequate volume to give a concentration of 50 ppm based upon the volume of the system being treated.
 - 3. The solution will be allowed to stand for a period of 24 hours.
 - 4. A minimum residual chlorine level of 5 ppm shall remain in each system for a minimum of 24 hours.
 - 5. After sterilization, all piping shall be thoroughly flushed.
 - 6. The above are minimum requirements and all sterilization procedures shall be in strict accordance with all local codes and authorities having jurisdiction.
 - 7. Under no circumstances shall the Contractor permit the use of any portion of the domestic water system until it has been properly sterilized and certified by the authorities having jurisdiction.
- G. Special requirements, if any, are specified in the Sections for each type of piping.
- H. After systems have been flushed, cleaned and sterilized; as required by specifications, provide written certification from the cleaning contractor that the systems are clean and ready for use.

3.8 LEAK TESTS

- A. All piping systems shall demonstrate leak tightness. This requirement shall be met by a water hydrostatic leak test or a pneumatic leak test, whichever is called for under specific piping Sections.
- B. Piping Systems:
 - 1. Test Preparation: Expansion joints shall be provided with temporary restraint, for the additional pressure load under test or shall be isolated from the test. Equipment and valves which are not rated for the pressure test shall be either disconnected from the piping or isolated by a blind flange or similar means.
 - 2. Test Pressure” The water hydrostatic test pressure shall be 1.5 times the design pressure. The pressure test shall be maintained for sufficient time to inspect all joints, with a minimum time of four hours.
 - 3. Special requirements, if any, for each system are specified in the Section for that system.

3.9 CONNECTIONS TO EQUIPMENT FURNISHED BY OTHERS

- A. Provide service connections to items of equipment furnished by others:
 - 1. Detailed shop drawings of equipment will be furnished indicating the exact number and location of rough-in points.
 - 2. Such final shop drawings may indicate adjustments in total number and exact location of rough-in points, and in equipment dimensions.
 - 3. Making adjustments to field conditions is considered a part of the work required.
- B. Roughing-In:
 - 1. When roughing-in, extend service piping to various items of equipment.

2. Temporarily terminate at proper points as indicated on detailed equipment shop drawings or as directed.
 3. Do not use contract drawings accompanying these specifications for rough-in locations but only for pipe sizing and general routing.
- C. Stop Valves:
1. Provide stop valves for each service at rough-in locations, except for drains.
 2. Stop valve locations are subject to approval, and in all cases must be accessible from the same room in which the furniture or equipment is located.
- 3.10 TEMPORARY CONDITIONING OF BUILDING SPACES FOR COMPLETION OF CONSTRUCTION
- A. Refer to Specification 22 05 00, Common Work Results for Plumbing, for requirements that must be completed prior to requesting the Owner to provide chilled water or hot water from the building distribution system.
- 3.11 PAINTING
- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Equipment supports.
- B. Division 03 Section - Concrete, for concrete requirements.
- C. Division 05 Section - Metal Fabrications, for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
- D. Division 09 Section - Painting, for painting requirements.
- E. Section 21 13 00 - Fire-Suppression Systems, for pipe hangers for fire-suppression piping.
- F. Section 22 05 00 – Common Work Results for Plumbing

1.2 DEFINITIONS

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

1.3 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Equipment supports.

- C. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Anvil
- B. Cooper B-Line
- C. Erico
- D. Unistrut
- E. Nibco
- F. PHP

2.2 CLEVIS TYPE HANGERS

- A. Adjustable steel clevis hangers (MSS1 Type 1)

2.3 METAL FRAMING SYSTEMS

- A. Provide fabricated cadmium plated steel framing members and appurtenances for interior pipe supports as shown:
 1. Mult-A-Frame, Unistrut, Cooper B-Line and Power-Strut pipe support systems also are acceptable.
 2. Support piping from precast and pan joist structure as detailed on Drawings.
 3. Powder actuated anchors are not permitted.
 4. Sleeves penetrating beams must be submitted through Structural Engineer. Refer to plumbing drawings for locations.
- B. Framing channel type support systems shall be 12-gauge cold-formed carbon steel conforming to ASTM A570 GR33:
 1. Fittings for framing channel system shall be punch pressed electro-galvanized carbon steel conforming to ASTM A575, A576, A635 and A36.
 2. Bolts and nuts shall have unified coarse screw threads with standard 1/2 inch nuts, conforming to ASTM A576 GR1015 AND ASTM A307.
 3. Components shall have a pre-galvanized zinc coating conforming to ASTM A525, except where indicated.

2.4 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier with vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

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

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Concrete: Provide 3,000 psi concrete. Reinforce slab with No. 4 rebar on 12 inch center each way centered in slab unless indicated otherwise on Drawings.
- C. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

2.9 ROOF PIPE SUPPORT SYSTEMS

- A. Supports for piping on roofs shall consist of molded reinforced nylon support base with black neoprene support pad and 3/8" diameter stainless steel continuously threaded rods, and hard cast rubber roller for pipe support, adjustable in height. Support shall be secured to roof, per roof manufacturers recommendations. Manufactured by MAPA Products No. MS4L, or approved equal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Metallic coatings for piping and equipment that will not have field-applied finish. All hangers and supports shall be cadmium plated. Hangers and supports in crawl space shall be hot dipped galvanized
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120°F to 450°F piping installations.
- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 - 8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

- 9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 - 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 - 3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified herein for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
 - 5. Pipes NPS 8 and Larger: Include wood inserts.
 - 6. Insert Material: Length at least as long as protective shield.
 - 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- N. Do not support piping from other piping.
- O. Where uninsulated (bare) copper pipe is supported by clevis hangers and riser clamps. The hangers shall be plastic coated or copper.
- P. Where uninsulated (bare) copper pipe is clamped to a dissimilar metal, such as steel, the copper pipe shall be installed with a felt isolator or Vibra Cushion No. B1999 manufactured by B-Line, Erico "Caddy" Cushion Clamp, or approved equal.

- Q. Isolation tape wrap is only acceptable where a clamp or support does not occur and where pipe is in connect with a building element.
- R. Place hangers not more than 6 feet apart on 1/2 inch and 3/4 inch pipes, or 10 feet apart on larger pipes unless noted otherwise on plans. Place hangers not more than 6 feet apart for all sizes of polyvinyl chloride pipe. Refer to manufacturer's recommendations for supporting polypropylene piping. For copper piping, place hangers as follows:
 - 1. For sizes up to 1 inch – maximum 5 feet - 0 inches O.C.
 - 2. For sizes 1-1/4 inch to 1-1/2 inch – maximum 7 feet - 0 inches O.C.
 - 3. For sizes 2 inches to 3 inches and larger – maximum 9 feet - 0 inches O.C.
- S. Support vertical risers as detailed on drawings at every floor:
 - 1. All water piping 2 inches or smaller shall be supported with galvanized steel strap pipe clamps of approved designed and sizes, properly supported at every floor.
 - 2. Support piping assemblies in chases adequately enough to be rigid and self-supporting before the chase is closed.
 - 3. Provide adequate structural support for piping penetrating chase walls to fixtures.
- T. Where insulation occurs, design hangers to protect insulation from damage. Pipe saddles and insulation shields, where required, are specified in the appropriate insulation Section.
- U. Perforated bar hangers, straps, wires or chains are not permitted.
- V. For cast iron piping, refer to specification section 22 13 16.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 22 11 16

DOMESTIC WATER PIPING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for furnishing and installing domestic hot and cold water piping, including hot water return within buildings.

1.2 RELATED SECTIONS

- A. Section 22 05 00 - Common Work Results For Plumbing
- B. Section 22 05 53 - Identification for Plumbing Piping and Equipment.
- C. Section 22 07 19 - Plumbing Piping Insulation.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic, potable domestic water piping and components.
- C. Comply with UL classified in accordance with ANSI/NSF 61 for hot and cold potable water service and shall be certified to the low lead requirements of NSF-372 for potable domestic water piping and components. Manufacturer must provide written documentation of compliance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements provide indicated products by manufacturers listed.
 - 1. Valves:
 - a. Apollo.
 - b. Crane.
 - c. Nibco.
 - d. Keystone.
 - e. Watts.
 - f. Milwaukee.
 - g. Hammond.
 - h. Kitz.
 - 2. Vacuum Breakers and Backflow Preventers:
 - a. Watts.

- b. Febco.
- c. Wilkins.
- d. Conbraco (Apollo).
- 3. Thermostatic Mixing Valves:
 - a. Lawler.
 - b. Bradley.
 - c. Powers
 - d. Symmons.

2.2 PIPING AND FITTINGS

- A. Aboveground (Including Trap Primer Piping): Provide seamless, ASTM B 88, Type L copper water tube with ANSI B16.22 wrought copper fittings with socket ends. Lead-free solder for all solder joints, Alloy Grade E in accordance with ASTM B32, similar to Engelhard Silvabrite 100. Joints for pipe fittings 2" and larger may be grooved type joints. Grooved End Fittings: All grooved end fittings shall be ANSI B16.18 cast bronze or ANSI B16.22 wrought copper, with copper-tube dimensioned grooved ends. (Flaring of tube or fitting ends to accommodate alternate sized couplings is not permitted.) Couplings shall consist of two ductile iron housing segments cast with offsetting angle-pattern bolt pads, pressure responsive grade EHP gasket, and zinc-electroplated steel bolts and nuts. Couplings shall be installation-ready, for direct stab installation without field disassembly. Victaulic Style 607. Flange Adapter Victaulic Style 641 roll grooved copper-tube dimensioned fittings sized 2" and larger. 3/8" diameter copper tube is allowed only where serving a single lavatory with a 0.5 gpm flow control device. Joints may also be Viega Pro-Press joining method with a non-toxic synthetic rubber elastomer seal (EPDM O-RINGS) with the fitting socket. The fitting shall be pressed under substantial pressure by power tool forming a joint rated for 200 psi and tested for 600 psi, approved by IAPMO IGC 137-99/PS 117-2000 & ANSI/NSF 61, fitting material shall conform to ANSI/ASM B16.22 & B16.18, approved by Uniform Plumbing Code.
- B. Unions: ANSI B16.22 Class 150, 300-pound water-oil-gas service wrought solder joint fitting such as NIBCO 633/733 union C x C, or approved equal.
 - 1. Flange joints larger than 2 inches shall be brass.
 - 2. Provide dielectric isolating unions or connections between metallic piping of dissimilar metal.
 - 3. Dielectric waterway fittings with grooved and/or threaded ends, as manufactured by Victaulic Company, Series 647, for sizes 1/2" through 8

2.3 VALVES

- A. Comply with requirements in Section 22 11 19, Domestic Water Piping Specialties, for balancing valves, drain valves, backflow preventers, and vacuum breakers.
- B. Ball Valves (pipe sizes through 2 inches): 600 psi WOG, cast silicone bronze body, ASTM B584 Alloy C87600, two piece reinforced Teflon seats, full port, blowout proof stem, quarter turn handle with stainless steel ball and stem with threaded ends, manufactured by NIBCO No. T-585-66-LF or approved equal.
- C. Butterfly Valves (2-1/2 inch and larger): Class 150, ductile iron body conforming to ASTM A-395, fully lugged, drilled body, lever operated, blow out proof type 316 stainless steel disc and stem, EPDM seat, suitable for bi-directional dead end service with downstream flange removed, minimum 175 psi bubble tight shut-off, manufactured by NIBCO No. LD-2000, or approved equal. For grooved systems Victaulic Series 608N or NIBCO GD-4765 are acceptable.

2.4 STRAINERS

- A. Y type, for pipe sizes 2 inch and less, class 125 rated for working pressure through 200 psig at 200°F, threaded ends, threaded cap, ASTM B62 cast bronze body and cap, 20 mesh stainless steel screen, openings not larger than 1/32 inch, tapped blowout outlet with minimum size of 1/4 inch, similar to NIBCO No. T-221-B, or approved equal.
- B. Y type, for pipe sizes over 2 inch, class 125 rated for working pressure of 200 psig at 150 degrees F, flanged ends, ASTM A126-B cast iron body, ASTM A36 carbon steel cover, non-asbestos gasket, type 304 perforated stainless steel screen, 1/16 inch perforations for pipe sizes up through 4 inch and 1/8 inch perforations for pipe sizes over 4 inch, with FDA approved internal lining. Manufactured by NIBCO No. F-721, or approved equal.

2.5 VACUUM BREAKERS AND BACKFLOW PREVENTERS

- A. Atmospheric Vacuum Breakers: Full line size, manufactured of brass or bronze with full size orifice, dry guide out of the liquid pressure area and disc float closing vent with minimum flow. Manufactured by Watts Regulator, No. 288A Series, or approved equal.
- B. Pressure Type Vacuum Breaker: Full line size, with full size orifices, manufactured of brass or bronze with double poppit (check valve) stainless steel screen and vent. Manufactured by Watts Regulator, No. 90, or approved equal.
- C. Reduced Pressure Backflow Preventer: Size as indicated on Drawings, manufactured of bronze, rated for 175 psi, and shall include strainer, gate or ball valves based on size, pressure differential relief valve, check valves, test cocks, and relief vent and funnel drain.
 - 1. Unit shall meet the requirements of ASSE 1013, and AWWA, University of Southern California tested and approved.
 - 2. Manufactured by Watts Regulator No. 909, or approved equal.
- D. Vacuum Relief Valve: 3/4 inch bronze with high temperature resisting disc, and disc guide located out of water.
 - 1. Tested up to 200 psi and 250°F and shall be open on a vacuum of not more than 1/2 inch of mercury.
 - 2. Manufactured by Watts Regulator No. N36G, or approved equal.
- E. High hazard, anti-siphon, anti-spill, vacuum breaker designed for indoor applications, featuring bronze body, one-piece modular check valve and float assembly, stainless steel springs, bronze quarter turn ball valves at inlet and discharge, University of Southern California tested and approved. Manufactured by Watts No. LF008PCQT, or approved equal.
- F. Dual Check Valve: Tested and certified to meet ANSI/ASSE Standard 1024, testable, cast bronze body, silicone discs, stainless steel springs, manufactured by Watts Series L7, or approved equal.

2.6 AIR RELIEF VENTS

- A. Float operated, constructed of cast iron with stainless steel float and trim and isolating valve:
 - 1. 1/2 inch, rated at 300 psi at 150°F.
 - 2. Vents shall be designed to eliminate air from the system automatically without permitting the passage of water.

3. Minimum 3/4 inch system connection (inlet), minimum 1/2 inch drain connection (outlet), 1/4 inch drilled, tapped and plugged test connection.
 4. Manufactured by Clark-Reliance, Model No. 6-V, or approved equal.
- B. For sizes under 2" (Point of Use at Equipment Connections): Automatic in operation, adjustable, renewable stainless steel seat, bronze body, adjustable from 25-75 psi outlet pressure, with stainless steel strainer screen, with gauge tappings, manufactured by Watts No. U5B, or approved equal.

2.7 THERMOSTATIC MIXING VALVES

- A. Provide rough bronze construction with a flow range of 1/2 gpm (minimum) through 6 gpm at 10 psi pressure loss with integral check stops, temperature adjustment range 95°F to 115°F, ASSE 1070 compliant, rough chrome, manufactured by Lawler Model 570, or approved equal. Provide within lockable recessed wall cabinet where serving wall mounted sinks or lavatories.

2.8 GROUT

- A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 CONNECTION

- A. Install unions downstream of all threaded valves and in all locations that supply serviceable equipment.
- B. Screwed Joints: Make joint with clean, full cut standard pipe threads. Ream after cutting and threading. Use heavy duty Teflon sealing compound or Teflon tape as threaded seal. Sealing compound shall be AGA and NSF certified, non-toxic, non-drying, anti-seize, and classified by UL.
- C. Use anti-seize compound on all bolts for flanges.
- D. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s)).

3.2 INSTALLATION

- A. For buried water service, clamp water pipe at fittings with 3/4 inch rods and properly anchor and support.
- B. Provide in-line strainer upstream of trap primers. Supply line to trap primers shall be taken off top of domestic cold water main, per manufacturer's recommendations.
- C. Provide a pressure gauge on each side of balancing valves on domestic hot water return loops.
- D. Provide backflow preventer certification documentation prior to final acceptance of system.
- E. No pulled tees (T-drill) are allowed.
- F. Provide a supply stop with union on the water supplies to each thermostatic mixing valve. Thermostatic mixing valve shall be located under lavatory counters hidden from view. At wall hung lavatories provide mixing valve concealed in wall with lockable wall access panel or lockable recessed wall cabinet.

3.3 DRAINAGE

- A. Install water piping systems with uniform horizontal grade of 1/8 inch per 10 feet, minimum, to low points to provide complete drainage of the system. Where constant pitch cannot be maintained for long runs, establish intermediate low points and rise to new level. Grade branches to drain to mains or risers. Unless otherwise indicated, terminate low points of risers with drain valve piped to nearest hub or floor drain.

3.4 IDENTIFICATION

- A. Identify system components. Comply with requirements in Section 22 05 53, Identification for Plumbing Piping and Equipment, for identification materials and installation.
- B. Label pressure piping with system operating pressure.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Piping Inspections:
 - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - 2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- C. Piping Tests:
1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 6. Prepare reports for tests and for corrective action required.
- D. Domestic water piping will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION

SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for furnishing and installing sanitary waste, soil and grease waste system piping and associated vent piping within buildings and underground laterals within 5 feet of building.

1.2 RELATED WORK

- A. Section 22 05 00 - Common Work Results for Plumbing.
- B. Section 22 05 53 - Identification for Plumbing Piping and Equipment.
- C. Section 22 05 29 - Hangers and Supports for Plumbing and Equipment.
- D. Section 22 14 23.13 - Roof Drainage Piping Systems

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 SUBMITTALS

- A. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; and "NSF-drain" for plastic drain piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Above Grade Piping:
 - 1. All aboveground sanitary sewer shall be cast iron soil pipe manufactured to ASTM A888, ASTM A74 and CISPI 301 or Cast iron soil pipe shall be listed with an ANSI Accredited Testing Agency for quality assurance and manufactured by Charlotte, Tyler or New Age (Epoxy).
 - 2. No-hub soil pipe and DWV pattern fittings conforming to ASTM A888 or CISPI301, and joined with a heavy duty coupling.
 - 3. Heavy duty shielded stainless steel couplings and tightening devices shall conform to ASTM C1540 with neoprene gasket conforming to ASTM C564.

4. 4-band no-hub couplings for pipe sizes 4 inches and less. 6-band no-hub couplings for pipe sizes over 4 inches..
 5. Couplings manufactured by Anaco "Husky" SD2000, Mission "HW" or Clamp-All 125 or New Age XHDC.
- B. Piping through Wall Sleeves: Provide section of ductile iron piping, as detailed, in wall penetrations.
- C. The p-trap for the floor drains receiving condensate shall be schedule 40 PVC with solvent cement joints, the remaining portion of the condensate drainage system shall be as specified in paragraph 2.01B & C herein.

2.2 VENT PIPE AND FITTINGS

- A. Vent pipe and fittings shall be same as specified for sanitary sewer herein.
- B. Provide heavy duty type 304 stainless steel minimum 4-band no-hub couplings, conforming to C.I.S.P.I. 310 as specified for drainage piping.
- C. Pipe shall conform to ASTM A 74, ASTM A 53 or ASTM B 306, where applicable.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Sanitary sewer piping outside the building is specified in Section 22 13 16, Sanitary Waste and Vent Piping.
- B. Basic piping installation requirements are specified in Section 22 05 00, Common Work Results for Plumbing.
- C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Section 22 05 00, Common Work Results for Plumbing.
- D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Section 22 05 00, Common Work Results for Plumbing.
- E. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- F. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- G. Vent Connections: Make vent connections to vent stacks with inverted wye fittings. Extend full-size vents through roof to at least 6 inches above roof.

- H. Flashing: Provide flashing as recommended by roofing material manufacturer and detailed by Architect/Engineer.
- I. Cleanouts:
 - 1. Install cleanouts the same size as the soil waste lines in which the cleanouts are placed. No cleanout should be larger than 4 inches in diameter.
 - 2. Where cleanouts occur in pipe chases, bring cleanouts through walls and install covers. Where cleanouts occur in floor slabs, set flush.
 - 3. Provide cleanouts where soil lines change every direction, every 50 feet on long runs, at end of each continuous waste line, and at the base of each riser.
- J. Floor Drains: Locate floor drains 1/2 inch below finish floor elevation unless shown otherwise.
- K. Slope sanitary waste piping at a uniform slope of 1/8" per foot for pipes sizes 3-inch and larger and 1/4" per foot for pipe sizes less than 3-inch. Slope vent piping at a uniform 1/8" per foot slope with the high point at the roof penetration, sloping back down toward the plumbing fixture. Refer to the plumbing code.
- L. Provide joint restraints on cast iron piping for pipe sizes over 4" and in changes in pipe diameter by two pipe sizes or more, and indicated in IPC Section 308, and conforming to CISPI 301-09. Joint restraints shall be Holdrite #117, or approved equal, or as shown on the Plumbing drawings.

3.2 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Section 22 05 00, Common Work Results for Plumbing.
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.
- C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- D. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.3 VALVE INSTALLATION

- A. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
 - 1. Use gate or full-port ball valve for piping NPS 2 and smaller.
 - 2. Use gate valve for piping NPS 2-1/2 and larger.
- B. Check Valves: Install swing check valve, downstream from shutoff valve, on each submersible pump discharge.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Seismic-restraint devices are specified in Section 22 05 48, Vibration Isolation for Plumbing Piping and Equipment.

- B. Pipe hangers and supports are specified in Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Install supports according to Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8 inch rod.
 - 2. NPS 3: 60 inches with 1/2 inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8 inch rod.
 - 4. NPS 6: 60 inches with 3/4 inch rod.
 - 5. Spacing for 10 foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 84 inches with 3/8 inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8 inch rod.
 - 3. NPS 2: 10 feet with 3/8 inch rod.
 - 4. NPS 2-1/2: 11 feet with 1/2 inch rod.
 - 5. NPS 3: 12 feet with 1/2 inch rod.
 - 6. NPS 4 and NPS 5: 12 feet with 5/8 inch rod.
 - 7. NPS 6: 12 feet with 3/4 inch rod.
- I. Install supports for vertical steel piping every 15 feet.
- J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 72 inches with 3/8 inch rod.
 - 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8 inch rod.
 - 3. NPS 2-1/2: 108 inches with 1/2 inch rod.
 - 4. NPS 3 to NPS 5: 10 feet with 1/2 inch rod.
 - 5. NPS 6: 10 feet with 5/8 inch rod.
- K. Install supports for vertical copper tubing every 10 feet.
- L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

- A. Connect soil and waste piping to existing sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

3.6 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Test pipe before backfilling and connecting to sewers by maintaining not less than 10 feet of hydrostatic head for 4 hours without a leak.
 - 2. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 3. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction.
 - 1. After all sections of soil, waste, and vent piping are installed, but before fixtures are connected, test system by plugging all outlets and filling vertical sections with water to maintain not less than 10 feet of hydrostatic head for 4 hours without any drop in water level for all sections of piping. Provide wyes as required to facilitate plugging.
 - 2. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 3. Prepare reports for tests and required corrective action.

3.7 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

SECTION 22 13 19

SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Drains.
 - 2. Cleanouts.

1.2 RELATED WORK

- A. Section 22 05 00 – Common Work Results For Plumbing.
- B. Section 22 14 23.13 – Roof Drainage Piping Systems.
- C. Section 22 13 16 – Sanitary Waste and Vent Piping.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following, except special custom trench drains which shall be only the specified manufacturer:
 - 1. Wade
 - 2. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - 3. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 4. Josam

2.2 DRAINS

- A. Design of drains is based on model numbers manufactured by Wade Drains, unless otherwise indicated. Subject to compliance with requirements, provide named product or comparable product by one of the listed acceptable manufacturers:
 - 1. Floor Drains (FD-1): Wade No. 1100-G6-1 or approved equal cast iron floor drain with flashing collar, seepage flange, nickel bronze 6 inch square adjustable strainer with square holes, vandal resistant secured grate.
 - 2. Floor Sink (FS-1): Wade No. 9110-1-26 or approved equal, cast iron 8" x 8" inch square floor sink with 6 inch sump, acid resistant coated interior, aluminum dome interior strainer, nickel bronze half grate, with flange and

2.3 CLEANOUTS

- A. Location:
1. Provide drainage lines with properly specified cleanouts.
 2. Locate cleanouts in runs not more than 90 feet on centers or as required by local authority having jurisdiction.
 3. Provide cleanouts at the base of each soil or waste stack and wherever necessary to make accessible all parts of the drainage soil or waste systems, whether or not indicated on drawings.
 4. Extend cleanouts within chases to near wall and provide wall access cover compatible with wall construction.
 5. Provide cleanouts of required size, with flashing flange where installed with membrane waterproofing.
- B. Finished and Unfinished Walls. Jay R. Smith 4430, duracoated, cast iron cleanout with cast bronze plug and chrome-plated bronze square frame and secured cover with vandal-proof screws.
- C. Finished Floors and Concrete Floors: Jay R. Smith 4020, adjustable duracoated, cast iron cleanout with tapered bronze plug and round nickel-bronze top and frame, with clamping collar. Provide carpet marker type for carpet floors.
- D. Exposed Piping. Jay R. Smith 4505, duracoated, cast iron calk ferrule and cast bronze plug with 1/2" NPT test port with raised head plug and internal threading for test plug use.
- E. Outside Area. Jay R. Smith 4220, duracoated, cast iron cleanout with taper thread bronze plug, adjustable housing, and heavy-duty tractor-type cover with vandal-proof screws, cast flush in a 16 inch x 16 inch x 6 inch thick concrete pad in nonsurfaced areas.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section 22 05 00, Common Work Results for Plumbing, for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

- a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- E. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 2. Size: Same as floor drain inlet.
- G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- H. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53, Identification for Plumbing Piping and Equipment.

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Water closets.
 - 2. Lavatories.
 - 3. Flush Valves.
 - 4. Fixture Carriers.
- B. Related Sections include the following:
 - 1. Section 22 05 00 - Common Work Results for Plumbing.
 - 2. Section 22 11 16 - Domestic Water Piping.
 - 3. Section 22 13 16 - Sanitary Waste and Vent Piping.

1.2 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- C. FRP: Fiberglass-reinforced plastic.
- D. PMMA: Polymethyl methacrylate (acrylic) plastic.
- E. PVC: Polyvinyl chloride plastic.
- F. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistant qualities.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

- C. Regulatory Requirements:
 - 1. Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
 - 2. Comply with requirements in Texas Senate Bill 587 for requirements about minimum water conservation performance requirements.
- D. NSF Standard: Comply with NSF 61, "Drinking Water System Components—Health Effects," for fixture materials that will be in contact with potable water.
- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - 1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - 2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - 3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 4. Stainless-Steel Residential Sinks: ASME A112.19.3.
 - 5. Vitreous-China Fixtures: ASME A112.19.2M.
 - 6. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
 - 7. Water-Closet, Flushometer Tank Trim: ASSE 1037.
- G. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 - 1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
 - 2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
 - 3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 - 4. Faucets: ASME A112.18.1.
 - 5. Hose-Connection Vacuum Breakers: ASSE 1011.
 - 6. Hose-Coupling Threads: ASME B1.20.7.
 - 7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 - 8. NSF Potable-Water Materials: NSF 61.
 - 9. Pipe Threads: ASME B1.20.1.
 - 10. Supply Fittings: ASME A112.18.1.
 - 11. Brass Waste Fittings: ASME A112.18.2.
- H. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
 - 1. Atmospheric Vacuum Breakers: ASSE 1001.
 - 2. Brass and Copper Supplies: ASME A112.18.1.
 - 3. Dishwasher Air-Gap Fittings: ASSE 1021.
 - 4. Manual-Operation Flushometers: ASSE 1037.
 - 5. Plastic Tubular Fittings: ASTM F 409.
 - 6. Brass Waste Fittings: ASME A112.18.2.
- I. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Disposers: ASSE 1008 and UL 430.
 - 2. Dishwasher Air-Gap Fittings: ASSE 1021.
 - 3. Flexible Water Connectors: ASME A112.18.6.
 - 4. Grab Bars: ASTM F 446.
 - 5. Hose-Coupling Threads: ASME B1.20.7.
 - 6. Off-Floor Fixture Supports: ASME A112.6.1M.
 - 7. Pipe Threads: ASME B1.20.1.

8. Plastic Toilet Seats: ANSI Z124.5.
9. Supply and Drain Protective Shielding Guards: ICC A117.1.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers.
- B. Water Closets, Lavatories:
 1. American Standard
 2. Kohler
 3. Crane
- C. Flush Valves:
 1. Sloan
 2. Zurn
- D. Lavatory Bowls:
 1. American Standard
 2. Kohler
 3. Zurn
 4. Sloan
- E. Lavatory Faucets:
 1. Chicago Faucets
 2. Symmons
 3. American Standard
 4. Moen
- F. Water Closet Seats:
 1. Church Seats.
 2. Beneke.
 3. Bemis Manufacturing Co.
 4. Toto.

2.2 WATER CLOSETS

- A. Wall-Hung Water Closets, Wheelchair (WC-1): Kohler "Kingston" K-4325 or approved equal, 1.28 gallon flush siphon-jet elongated vitreous china bowl with 1-1/2" top spud.
 1. Equip with the following:
 - a. Sloan Royal "Optima" Royal Model 111-1.28, exposed with 1.28gallon per valve with vacuum breaker,
 - b. Sweat kit.
 - c. Vandal resistant stop cover and controls.
 - d. Cast wall escutcheon
 - e. 1" screwdriver angle stop and 1-1/2" connection.
 - f. Electrical hard wired powered with step down transformer. Serves up to 10 flush valves. Coordinate with Division 26. Sloan Model No. EL-154 transformer
 - g. Church "MOLTEX" No. 9500C white, solid plastic, open-front elongated seat with stainless steel check hinge, without cover.

- h. Dual filter bypass kit.
- i. True mechanical manual override button.

2.3 LAVATORIES

- A. Lavatory (L-1):
 - 1. Bowl: Kohler "Kingston" No. K-2007-0 or approved equal, 20" x 18" rectangular vitreous china wall-hung lavatory punched for single hole faucets, and ADA compliant.
 - 2. Trim: Symmons Model S-71-A or approved equal, single hole deck mounted, ADA compliant push top metering faucet, 0.25 gallons per cycle, chrome plated finish, and 1.25 gpm vandal resistant aerator.
 - 3. Supplies: McGuire No. 2165LKSS-16 , 1/2" x 3/8" x 16" long flexible mesh stainless steel riser tubing with loose key angle stop, riser nipple to wall, and chrome escutcheon.
 - 4. Traps: McGuire No. 8902, 1-1/4 inch x 1-1/2 inch adjustable 17 gauge cast brass P-trap, with cleanout plug, cast brass escutcheon, chrome finish.
 - 5. Drain: McGuire No. 155WC, Chrome plated brass offset style strainer with 1-1/4 inch O.D. tailpiece, 17 gauge, ADA compliant.
 - 6. Insulation Kit: TRUEBRO, or approved equal, fully molded closed cell vinyl, ADA approved insulation kit complete with interlocking trap assembly, hot and cold-water angle valve assembly, and factory-supplied fasteners.
 - 7. Provide ASSE 1070 compliant thermostatic mixing valve with a maximum outlet temperature of 110 degrees F, refer to spec. section 22 11 16, within recessed wall box. Refer to floor plans and plumbing riser diagrams for mixing valves serving more than (1) single fixture. One mixing valve can serve more than one fixtures where fixtures are grouped.

2.4 FIXTURE CARRIERS

- A. Water Closet Carriers: Wade Series 310, 330, 340 & 350 or approved equal by Zurn, or Jay R. Smith.
 - 1. Adjustable heavy duty (for extra heavy weight support - minimum 500 lbs. capacity by independent testing lab) cast iron horizontal or vertical integral carrier fitting with neoprene faceplate gasket and anchoring feet, complete with rear anchor support.
- B. Lavatory Carriers: Wade 520 Series or approved equal by Zurn or Jay R. Smith
 - 1. Free-standing adjustable for concealed arms, steel uprights, bearing plate and anchoring feet plate, ductile iron arms, invertible headers.
- C. strobe light, 120 volt single phase power requirement, 12' of cable, manufactured by Bradley No. S19-320C, or approved equal.

2.5 WATER HAMMER ARRESTORS

- A. Provide hydraulic shock absorbers in cold and hot water supply lines to each individual plumbing fixture or battery of fixtures, and at each automatic, solenoid-operated or quick-closing valve serving mechanical, kitchen or laundry equipment. Shock arrestors shall be of seamless type "K" copper body construction or type 304 stainless steel body with stainless steel bellows, nitrogen and helium gas pre-charged. Shock arrestor shall be certified to ASSE 1010-2004 Standard and listed with IAPMO, completely sealed and operating free of casing. Size all units according to water hammer arresters standard PDI-WH-201. The shock arrestor shall have a life time warranty and shall be designed to provide continuous protection without maintenance allowing the shock arrestor to be

installed without an access panel. Manufactured by Sioux Chief "Hydra-Rester", Wade, Jay R. Smith and FNW.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install wall-mounting fixtures with tubular waste piping attached to supports.
- E. Install fixtures level and plumb according to roughing-in drawings.
- F. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
- G. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- H. Install toilet seats on water closets.
- I. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- J. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
- K. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- L. Install traps on fixture outlets:
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- M. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Section 22 05 00, Common Work Results for Plumbing.
- N. Refer to Architectural drawings for fixture mounting heights.
- O. Provide an ASSE 1070 compliant thermostatic mixing valve on the domestic hot water and cold water supply piping serving sinks, lavatories, with a maximum outlet temperature of 105 degrees F.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 requirements.
- D. Provide access doors for maintenance access to shock arrestors. Access doors shall be stainless steel, unless otherwise indicated on Architectural drawings.
- E. The installation of roughins and carriers of water closets shall be inspected by Owner and/or Engineer prior to coverup. The supports/carriers for water closets shall be securely anchored to the floor and shall be heavy weight type carriers, rated to support a minimum of 600 lbs.
- F. For sinks indicated to be provided by Division 22, provide the same supply stops as specified for sinks herein. Compression connections are not allowed.
- G. Install shock arrestors on pipe headers for fixture groups in locations shown on plumbing riser diagrams and as recommended by the manufacturer. Domestic water supplies to single plumbing fixtures shall be provided with shock arrestors. The use of only air chambers as shock protection is not allowed.

3.3 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.4 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.

- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

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10/3/2016

Shah Smith & Associates, F-2113

SECTION 23 00 1

MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Except as modified in this Section, General Conditions, Special Conditions, applicable provisions of Division 01, General Requirements, and other provisions and requirements of the contract documents apply to work of Division 23.
- B. Applicable provisions of this Section apply to all Sections of Division 23 HVAC.
- C. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements, and provide coordination drawings.
- D. All work in these Sections shall be installed by craftsmen skilled in their trade.
- E. [Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019000, General Commissioning, for detailed commissioning requirements.

1.2 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. Furnish: The term "furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- G. Install: The term "install" is used to describe operations at project site including the actual unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.

- H. Provide: The term "provide" means to furnish and install, complete and ready for the intended use.

1.3 CODE REQUIREMENTS AND PERMITS

- A. Perform work in accordance with applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.
- B. Resolve any code violation discovered in contract documents with the Engineer prior to award of the contract. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.
- C. Obtain and pay for all permits and inspections.
- D. The following building codes are applicable to this project.
 - 1. 2012 International Mechanical Code
 - 2. 2012 International Building Code
 - 3. 2009 International Energy Conservation Code
 - 4. State Energy Conservation Office (SECO) mandated state building compliance with ASHRAE 90.1-2010

1.4 REFERENCES

- A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, AWWA Specifications, Federal Standards or other standard specifications must comply with latest editions except where specified otherwise in individual Sections, revisions, amendments, or supplements in effect on date bids are received.
- B. Requirements in reference specifications and standards are minimums for all equipment, materials and work. In instances where capacities, size or other features of equipment, devices, or materials exceed these minimums, meet listed or shown capacities.

1.5 SUBMITTALS

- A. Equipment and Materials submittals must show sufficient data to indicate complete compliance with contract documents as follows:
 - 1. Proper sizes and capacities.
 - 2. That the item will fit in the available space in a manner that will allow proper service.
 - 3. Construction methods, materials, and finishes.
- B. Material and Equipment List: Within 30 days after award of the contract and before orders are placed or shop drawings are submitted, submit a list of equipment and principal materials specified. Give names of manufacturers, catalog and model numbers, and such other supplementary information as necessary for identification.
- C. Material and Equipment Shop Drawings: Submit all detailed shop drawings, descriptive literature, physical data, and performance data for review for items of equipment and for principal materials proposed for installation. HVAC controls may be submitted separately provided the controls submittal is complete and coordinated with all other applicable trades. Include identifying symbols and equipment numbers

used in plans and specifications, with reference to specification paragraphs, and drawing numbers of all equipment and material submitted.

- D. Final Submittal: In addition to number of copies of shop drawings and other data required for review submittals, maintain a separate file of final approved copies of such material. Deliver approved copies in a hard-back binder for the Owner's use. Incorporate changes and revisions made throughout construction period. Delivery of approved copies is a condition of final acceptance for the project.
- E. Contractor's Check: Shop drawings will be submitted only by the Contractor. Indicate by signed stamp that the drawings have been checked, that the work shown on the drawings is in accordance with contract requirements and that dimensions and relationship with work of other trades have been checked. If drawings are submitted for approval that have not been checked and signed by the Contractor, they will be returned for checking before being considered by the Architect/Engineer.
- F. Refer to Section 01 33 00 for additional submittal requirements

1.6 COORDINATION DRAWINGS

- A. Prior to starting work, the Contractor shall provide coordination drawings for all areas of the building.
- B. CAD. Provide 1/4 inch scale coordination drawings for all areas of the buildings for approval by Architect/Engineer.
 - 1. Drawings shall show all equipment, ductwork, cable trays, fire protection system, coil pull spaces, chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room to verify space allocation and coordination of trades.
 - 2. Provide plan and elevation views detailing installation.
 - 3. Drawings shall include 1/4 inch scale drawing of each mechanical room. Drawing shall show coil pull spaces and coordination of all ductwork, all chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room. Provide plan and elevation views detailing installation
 - 4. Contractor may not proceed with construction of MEP systems until Drawings have been reviewed by the Architect, Engineer and Owner.
- C. Composite. The respective Sub Contractors shall prepare one complete set of composite drawings.
 - 1. The sheet metal shop drawings shall be used as the basis for this coordination. When the sheet metal drawings have been prepared, the electrical conduit, mechanical piping, plumbing piping and fire protection piping shall be overlaid and drafted onto the composite drawing. In renovation areas, contractor shall revise existing structural and architectural backgrounds as required to resolve conflicts to match field conditions exposed during demolition operations. The intent of this process is to define areas of potential conflict and resolve those conflicts prior to fabrication or installation of any work.
 - 2. In area of congestion (where simply overlaying and drafting will create an unreadable product) the plan view scale shall be increased and/or multiple layered views shall be developed. Elevations of the individual elements shall be established and elevations shall be drawn to illustrate that the ductwork, piping, conduit, etc. will co-exist within the available space and

that the proper access to equipment, valves, filters, etc. has been established for operation, service, removal and replacement.

3. The completed "Composite Drawings" shall be submitted to the architect for review prior to installation. Any work that proceeds without appropriate coordination and review will be subject to removal and relocation at no additional cost.

1.7 INTERFERENCE DRAWINGS

- A. Interference drawings are drawings that indicate conflict between the various systems and other components of the building such as beams, columns, walls, etc. They shall be drawn to scale and shall include plans, elevations, sections and other details as required to clearly define the interference and to indicate the contractor's proposed solution.
- B. They shall be submitted for approval whenever job measurements and an analysis of the drawings and specifications by the contractor indicate that the various systems cannot be installed without significant deviation from the intent of the contract. When such interference is encountered, work shall cease in the general area of the conflict until a resolution to the question has been approved.

1.8 GUARANTEE

- A. Guarantee work for one year from the date of final acceptance of the project. During that period make good any faults or imperfections that may have arisen due to defects or omissions in materials or workmanship.

1.9 SERVICE

- A. Perform service work required during the guarantee period including lubrication of bearings. Perform manufacturer's recommended monthly service and provide Owner with written report. Cleaning of air filters and pipe strainers is not included.

1.10 RESOLUTION OF CONFLICTS

- A. Where conflicts may exist between and/or within the drawings and/or specifications, the higher quality, greater quantity, more restrictive, and/or more expensive requirement shall be required and shall be the basis of Contractor pricing. The Contractor shall notify the A/E for resolution of the issue prior to executing the work in question.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Furnish new and unused materials, pipes, pipe fittings, and equipment of domestic manufacture, where available. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

2.2 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are listed in individual Sections of Division 23. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

- B. Manufacturers' names and catalog numbers specified under Sections of Division 23 are used to establish standards of design, performance, quality and serviceability and not to limit competition.
- C. Equipment of similar design, equal to that specified, manufactured by a manufacturer named in the acceptable manufacturers' list will be acceptable on approval.
- D. Substitutions:
 - 1. If the Contractor desires to substitute a material or method as an equal to the specified item, he shall request permission from the Architect/ Engineer, in writing, and shall include such literature, samples, etc., deemed necessary to establish the equal quality of his proposal.
 - 2. If the Architect/Engineer deems it necessary in order to establish the equality between two or more products, he may require laboratory testing at the Contractor's expense in order to obtain information upon which to base a decision.
 - 3. The Architect/Engineer will not give approval to material salesmen or subcontractors, and only in writing to the successful Contractor after the project has been awarded.
 - 4. For each proposed substitution product, clearly show how the proposed product meets the requirements of the specifications, including performance.
 - 5. No substitution will be considered unless it is presented in writing within that number of days after Notice to Proceed equal to 15 percent of the contract time.
 - 6. Proposers of substitute products shall present samples, literature, test and performance data, record of other installations, names of Owners, architects, engineers, contractors and subcontractors as references, statement of current financial condition, and other technical information applicable to their products, to aid in determining the worth of the substitute product offered in relation to the material and work specified from the standpoint of the Owner's best interest. Substitute materials and products shall be used only if approved in writing by the Architect/Engineer in advance.
 - 7. Approval of substitute materials offered shall not be a basis for contingent extra charges because of changes in other work or related work, such as roughing-in, electrical, structural or architectural, which may result from the substitution.
 - 8. For any Contractor initiated substitutions or changes, Contractor shall be responsible for achieving results equal to or better than the product or design originally specified.

2.3 NOISE AND VIBRATION

- A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate (without cost to the Owner) that equipment performs within designated vibration limits indicated in the specifications, or as specified by manufacturer.
- B. Seal all wall and partition penetrations (the penetration opening shall be one inch larger than penetrating member) by ducts and piping by stuffing the annular void

with fiberglass insulation and then caulking over fully with a non hardening acoustical caulking applied to both sides of wall or partition.

2.4 AIR FILTERS AND PIPE STRAINERS

- A. Immediately prior to final acceptance of project, inspect, clean and service hydronic system strainers and replace disposable type air filters.
- B. Turn over to Owner additional sets of spare filters and other spare parts as specified.

2.5 ACCESS DOORS

- A. Provide access doors for all walls or ceiling locations as required for access to valves, controls, regulating devices, water arresters, fire dampers, air distribution boxes, and other concealed equipment requiring maintenance adjustment or operation. Coordinate location with General Contractor.
- B. Basis-of-Design Product: Design of access doors is based on model numbers manufactured by Milcor unless otherwise indicated. Subject to compliance with requirements, provide named product or approved equal.
 - 1. Non-Fire Rated Doors:
 - a. Furnish Milcor non-fire rated doors with 16-gage frames and 14 gage door panels.
 - b. Provide continuous concealed hinges and flush screwdriver cam lock.
 - c. Use Style M for prime painted steel, and MS for stainless steel.
 - d. Use Style DW access door for drywall or gypboard construction.
 - e. Use Style CF for suspended drywall ceilings.
 - f. Use Style K for plastered walls and ceilings.
 - g. Use Style AP for acoustical plastered ceilings with all galvanized construction.
 - 2. Fire-Rated Access Doors:
 - a. Furnish Milcor, UL listed, 1-1/2 hour, "B" label for service access in walls of stairwell, corridors and all other areas where fire-rated construction occurs.
 - b. Access doors shall have a 16 gage steel frame and 20 gage insulated sandwich type insulated panel.
 - c. Use ATR for fire-rated suspended drywall ceilings.
 - 3. Provide spring-loaded door for automatic closure and exterior key lock for security.

2.6 FLAME SPREAD PROPERTIES OF MATERIALS

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Cooperation with Other Trades: Cooperation with trades of adjacent, related, or affected materials or operations and of trades performing continuations of work under subsequent contract is considered a part of this work in order to effect timely and accurate placement of work and to bring together in proper and correct sequence the work of such trades.
- B. Workmanship: Work must be performed by workmen skilled in their trade.
- C. Installation of all equipment and materials must be complete. Installation shall meet requirements of specifications and manufacturer's recommendations.
- D. Electrical Wiring of Motors and Equipment. The Contractor shall note that the electrical design was based upon the mechanical equipment indicated on the mechanical construction documents and specifications. If Contractor proposes any mechanical equipment that requires changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.

3.2 SPACE REQUIREMENTS

- A. Consider space limitations imposed by contiguous work, including clearances required for service, in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.
- B. The following space allocation and coordination shall be followed, unless otherwise indicated on the construction drawings:
 - 1. Gravity-fed plumbing and roof drain line shall take priority over all other systems.
 - 2. Light fixtures and cable tray arrangements shall take priority in spatial layout. In areas with ceilings, other systems shall be routed above the light fixtures, and offset from above cable tray allowing for access and maintenance clearance.
 - 3. Install HVAC ductwork as close to the bottom of structural framing as possible while allowing clearance for installation of insulation wrap. Install ductwork to be accessible from the ceiling plane.
 - 4. Install HVAC chilled/hot water piping in the plane directly below HVAC ductwork unless indicated otherwise on drawings.
 - 5. Install fire sprinkler piping in the plane directly beneath the HVAC chilled/hot water piping. Do not install sprinkler piping directly below equipment requiring maintenance.
 - 6. Install domestic hot and cold water in the plane directly above the light fixtures.
 - 7. Refer to Division 26 for electrical and control wiring requirements.
 - 8. Install piping to permit removal of coils at air handling units and to permit access to all terminal unit components.

3.3 OBSTRUCTIONS

- A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.

- B. Before any cutting or trenching operations are begun, verify with Owner's Representative, utility companies and other interested parties that all available information has been provided. Verify locations given.
- C. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.
- D. Assume total responsibility for and repair any damage to existing utilities or construction.

3.4 OPENINGS

- A. Framed, cast or masonry openings for ductwork, equipment and piping are specified under other divisions. However, drawings and layout work for exact size and location of all such openings are included under this division.

3.5 ACCESS DOORS

- A. Coordinate location of access doors for ease of operation and maintenance of concealed equipment.

3.6 DELIVERY, STORAGE AND HANDLING

- A. Adequately protect work, equipment, fixtures and materials from damage during storing, installation, start-up and testing.
- B. Cover all equipment stored exposed to elements with waterproof tarps, provide adequate ventilation.
- C. At work completion, all work must be clean and in like new condition.
- D. Storage of all mechanical equipment, piping materials and ductwork shall be in strict accordance with manufacturers written installation instructions.
- E. Rotate air handler fans and pump shafts on routine basis.
- F. Provide factory installed pipe caps for all pipes to be installed on the project.
- G. Provide covers over all openings in ductwork stored or installed on the project.
- H. Energize motor heaters with temporary power as soon as the motor is received on site.
- I. Air Handling Units shall not be used as storage containers

3.7 LUBRICATION AND OIL

- A. Provide a complete charge of correct lubricant and/or oil for each item of equipment requiring lubrication.

3.8 PAINTING

- A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections for Interior Painting and Exterior Painting.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
- C. Paint mechanical items located outdoors, in building equipment rooms, in tunnels and on roof. Painting of mechanical systems includes preparing, painting, and color coding work.
- D. Preparation and application shall be in accordance with Division 09 Painting Sections.
- E. Mechanical items to be painted include, but are not limited to, piping, pipe hangers, heat exchangers and tanks, mechanical equipment, insulation, equipment supports, motors, and ductwork.
- F. Thoroughly clean surfaces receiving paint of dirt, grease, oil, rust, and scale.
- G. Unless otherwise specified, paint using three coats of selected colors. Mix and use exactly as specified by manufacturer. Allow each coat to dry thoroughly before applying succeeding coats. Painting may be done by spraying where feasible.
- H. Upon completion of painting, remove all scaffolds, surplus material, rags, and trash to leave spaces neat and clean.
- I. Machinery and Equipment: Paint motors, compressors, tanks, air handling units, and other similar equipment according to the following requirements:
 - 1. First Coat: Rust inhibitive primer (not required if factory painted). Use galvanized iron primer where applicable.
 - 2. Second Coat: Machinery enamel. Factory finished items require matching touch up only.
 - 3. Third Coat: Machinery enamel.
- J. Piping and Ductwork:
 - 1. First Coat: Rust inhibitive primer. Use galvanized iron primer where applicable. Omit first coat on pre-sized insulated pipe.
 - 2. Second Coat: Enamel.
 - 3. Third Coat: Enamel.
- K. Pipe Coding:
 - 1. Paint all piping white. Each line shall receive pipe marker as specified.
 - 2. Paint pipe in accordance with the following painting schedule:

PAINTING SCHEDULE
Color Code – Finish Coats

<u>Item</u>	<u>Color</u>
Treated Water	Federal Safety White
Drain and Exhaust	Navy Gray
Caustic	Federal Safety Red
Acid and Chemical	Federal Safety Purple
Chilled Water	Cascade Green

PAINTING SCHEDULE
Color Code – Finish Coats

<u>Item</u>	<u>Color</u>
Condenser Water	Federal Safety Green
Air	Marlin Blue
Anything Hot	Federal Safety Orange

3.9 CUTTING AND PATCHING

- A. General: Cut and patch walls, floors, etc., resulting from work or by failure to provide proper openings or recesses in new construction.
- B. Methods of cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer.
 - 1. Do not use impact-type equipment except where specifically acceptable to the Architect/Engineer.
 - 2. Core drill openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., to exact size.
- C. Restoration: Restore all openings to "as-new" condition under the appropriate Specification Section for the materials involved
- D. Match remaining surrounding materials and finishes.
- E. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry.
- F. Provide adequate support during cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.
- G. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

3.10 TEMPORARY CONDITIONING OF BUILDING SPACES FOR COMPLETION OF CONSTRUCTION

- A. The following mechanical system items shall be completed prior to requesting the Owner to provide chilled water or hot water from the campus distribution system:
 - 1. All chilled and hot water piping systems must be complete.
 - 2. All hydronic-piping systems must be cleaned in accordance with specifications.
 - 3. All chilled water piping must be insulated and sealed.
 - 4. All pumps, air handlers and other associated equipment must be installed in their permanent location with all valves, strainers, piping, vibration isolation, electrical connections and safety devices in place.
 - 5. Controls to regulate temperature and water flow must be in place and operational.
 - 6. Provide and service fine mesh construction inserts in pump strainers.

- B. All permanent filters for air handlers must be in place. Temporary filters must be installed on VFD drives during construction. Provide temporary filter media ahead of permanent filters and replace when dirty. Do not operate exhaust devices during gypboard finishing.
- C. Factory startup of the VFD drives shall occur prior to turning on units.
- D. A preliminary air balance of the supply air shall be performed within one week of start-up by the TAB firm. All air unit and fan motors amperage ratings shall be measured and provided to the owner in the preliminary Air Balance Report.
- E. All equipment utilized will be checked out by a factory representative, serviced, lubricated, checked for rotation, pressure, amp draw and vibration isolation, adjusted and certified. Record of this service must be provided monthly to the Owner. Submit appropriate reports to the University prior to submitting a written request for service.
- F. All equipment operated shall be serviced on a regular basis by the contractor.
- G. Prior to final inspection, clean all equipment inside and out to a like new condition, remove temporary filters, install new permanent filters in preparation for final inspection by Owner.
- H. All warranties will be commenced at the time of final acceptance.

3.11 OPERATING TESTS

- A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation witnessed by Owner's Representative.
- B. Prove operations of control systems and all safeties, freezestats and alarms.
- C. Make adjustments as required to ensure proper functioning of all systems.
- D. Special tests on individual systems are specified under individual Sections.
- E. Functional Performance Testing is part of the Commissioning Process. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Agent. Refer to Section 019113, General Commissioning, for functional performance testing and commissioning requirements.

3.12 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Furnish copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings in accordance with Specification 01 78 23. Detailed requirements for these items are as follows:
 - 1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies

to the equipment and information which does not apply. Data shall include as a minimum the following items:

- a. Recommended procedures and frequencies for preventive maintenance; inspection, adjustment, lubrication, cleaning, etc.
 - b. Special tools and equipment required for testing and maintenance.
 - c. Parts lists reflecting the true manufacturer's name, part number and nomenclature.
 - d. Recommended spares by part number and nomenclature and spare stocking levels.
 - e. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
 - f. Troubleshooting, checkout, repair and replacement procurement procedures.
 - g. Operating instructions including start up and shutdown procedures.
 - h. Safety considerations including load limits, speed, temperature and pressure.
2. Provide O&M manuals for all HVAC equipment.

3.13 PROJECT RECORD DOCUMENTS

- A. Maintain at the job site a separate set of white prints of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is significantly at variance with the contract drawings.
- B. Mark the drawings with a colored pencil.
- C. Prepare, as the work progresses and upon completion of work, drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed.
- D. At conclusion of project, obtain without cost to Owner, reproducibles of original mechanical drawings and transfer as-built changes to these.
- E. Delivery of as-built prints and reproducibles is a condition of final acceptance.

3.14 TRAINING

- A. Upon completion of work, and at time designated by the Owner's Representative, provide services of a competent representative of the manufacturer/Contractor to instruct the Owner's Representative and up to 8 members of the Owner's staff in the operation and maintenance of the entire system. Record training sessions on DVDs for instructing future technicians.

B. Provide training for the following pieces of equipment:

Items:	HRs of Training Pre-Substantial Completion	HRs of Training at 6 months from Substantial Completion	HRs of Training at 11 months from Substantial Completion	Video Taping Required
DDC Controls	4			X
VFDs	4			X
Fan Coil Units	4			X

- C. All training sessions shall be scheduled in coordination with the Owner's Representative 14 days in advance, attendance taken, and sign-in sheet and training materials included in the O&M manuals. Refer to Section 019113, General Commissioning, for additional contractor training requirements.

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general requirements for 1-phase and 3-phase electric motors with NEMA frame machines sized through 200 horsepower and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation. Unless otherwise specified, provide motors meeting the basic requirements for general purpose alternating current motors, as defined in ANSI/NEMA MG 1-1.05.

1.2 COORDINATION

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

1.3 REFERENCES

- A. ANSI/IEEE 117 - Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound AC Electric Machinery.
- B. ANSI/NEMA MG 1 - Motors and Generators.
- C. ANSI/NEMA MG 2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors.
- D. ANSI/UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations.
- E. ANSI/UL 1004 - Electric Motors.
- F. Energy Conservation Design Standard for New State Buildings.

1.4 SUBMITTALS

- A. Provide the following information for each motor:
 - 1. Manufacturer.
 - 2. Rated full load horsepower.
 - 3. Rated volts.
 - 4. Number of phases.
 - 5. Frequency in hertz.
 - 6. Full load amperes (FLA).
 - 7. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
 - 8. Nominal speed at full load (rpm).
 - 9. Service factor.

10. NEMA design letter.
 11. NEMA machine type (ODP, WP-I, TEFC, etc).
- B. For motors 3/4 horsepower and larger, include the following additional information:
1. NEMA frame size.
 2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance with the intent of paragraph 2.3C.
 3. Maximum ambient temperature for which motor is designed.
 4. Time rating.
 5. Bearing type.
 6. Efficiency at full load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements for integral horsepower motors, provide products by one of the following:
1. General Electric.
 2. Baldor/Reliance.
 3. Toshiba
 4. TECO Westinghouse.

2.2 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.3 MOTOR CHARACTERISTICS

- A. Speed and Size:
1. Speed and approximate horsepower ratings are specified in the driven equipment specification Sections or are indicated on the Drawings.
 2. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity.
 3. Size motors so as not to overload at any point throughout the normal operating range.
 4. Provide motors designed and rated for variable frequency drive applications where required.
- B. Voltage:
1. Single phase: 115 volts for 120-volt nominal system voltage and 277 volts (refer to mechanical schedules).
 2. Three phase: 480 volts for 480-volt nominal system voltage.
- C. Frequency: 60 hertz.
- D. Service Factor: According to NEMA MG 1-12.47 but not less than 1.15.

- E. Acceleration Time: For integral horsepower motors, the calculated acceleration time of the combined motor and driven load shall not exceed 4 seconds at 90 percent of rated voltage.
- F. Efficiency:
 - 1. Provide single-speed NEMA Design B Premium efficiency induction motors having minimal full-load motor efficiency no less than those listed in the latest edition of NEMA MG 1 Section 12.60 (EFFICIENCY LEVEL OF PREMIUM EFFICIENCY ELECTRIC MOTORS). Motors and manufacturers shall be officially listed and labeled by the NEMA Premium program.
 - 2. Base motor efficiencies on a statistically valid control procedure conforming to ANSI/IEEE 112-84, Test Method B (Dynamometer), using NEMA MG 1).

2.4 DESIGN TYPE

- A. Motors Smaller than 1/6 Horsepower: Single-phase squirrel-cage induction motors with integral thermal protectors.
- B. Motors 1/6 through 1/2 Horsepower: Single-phase NEMA Design Letter N, squirrel-cage induction motors with integral thermal protectors.
- C. Motors Larger than 1/2 Horsepower: 3-phase, NEMA Design Letter B, squirrel-cage induction motors.
- D. Motor Driven by Variable Frequency Drives (VFDs): Inverter duty motors.

2.5 MOTOR INSULATION

- A. Temperature Rise B Temperature Rise: NEMA MG 1-12.41 for fractional horsepower motors and NEMA MG 1-12.42 for integral horsepower motors.
- B. Outdoor Suitability:
 - 1. Where motors must be suitable for outdoor installation, insulation must withstand 1 full week (168 hours) of testing in a chamber maintained at 100 percent relative humidity and 40°C ambient temperature.
 - 2. Immediately after the test period, insulation system must have a minimum resistance of 1.5 megohms.
 - 3. Coat inside circumference of the stator and the outside circumference of the rotor and shaft with the same moisture-resistant insulation system.
- C. VFD Motors: Inverter duty type and capable of withstanding repeated peaks of 1600 volts at 0.1 microsecond rise time. Comply with NEMA MG-1 Part 31.

2.6 LEADS

- A. Use not less than ASTM B 173, Class G, stranded copper conductors with insulation the same as or better than specified in the preceding Motor Insulation paragraph.
- B. Provide permanent identification numbers on leads according to NEMA MG 1-2.02.
- C. Use crimp-on, solderless copper terminals on leads and place heat-shrink insulation sleeves or covers between leads and terminals.

2.7 ENCLOSURE

- A. Indoors:
 - 1. Open drip-proof (ODP).
 - 2. Use steel frame for motors smaller than 3/4 horsepower and up to 10 HP.
- B. Outdoors: Completely enclosed, fan cooled (TEFC), with a corrosion-resistant drain plug under each bearing. Use cast-iron frame.

2.8 BEARINGS

- A. Motors Smaller than 1/6 Horsepower: Motor manufacturer's standard bearing is acceptable.
- B. Motors 1/6 Horsepower and Larger:
 - 1. Antifriction:
 - a. Supply motors with grease-lubricated antifriction ball bearings conservatively rated for long life under the total radial and thrust loads produced by the actual combination of motor-driven equipment.
 - b. Provide each motor with suitable lubrication fittings and pressure relief devices suitable for in-service lubrication.
 - 2. Oil Lubricated: If the driven equipment Section specifies oil-lubricated bearings for motors, include a suitable sight gauge on each bearing with maximum and minimum levels clearly indicated.

2.9 HARDWARE

- A. Use structural bolts, washers, nuts, pins, and similar items manufactured of high-strength steel. Use only hexagon-head bolts and hexagon nuts.
- B. Use corrosion-resistant materials or protect hardware from corrosion by hot-dip galvanizing, chrome plating, or cadmium plating.

2.10 NAMEPLATES

- A. Main Nameplate: Provide each motor with a stainless steel nameplate meeting the requirements of NEMA MG 1-10.38, and the National Electrical Code, Section 430-7. Identify energy-efficient motors in accordance with MG-1-12.54.2.
- B. Bearings Nameplate: When bearings are oil lubricated, include oil type information on a suitable nameplate. Indicate bearing data if nonstandard.
- C. Attachment: Attach the nameplates to the motor with stainless steel fastening pins or screws.

2.11 CONDUIT BOX

- A. For each motor not supplied with a cord and plug, provide a conduit box suitably sized for the motor lead terminations, in accordance with the National Electrical Code, Section 430-12. Include a grounding lug for motors 1/6 horsepower and larger. Supply a gasket suitable for the motor enclosure type and application.

2.12 PAINT

- A. Manufacturer's standard shop paints for prime and finish coats are acceptable.

2.13 NOISE

- A. Provide integral horsepower motors with overall sound power levels meeting the requirements of MG 1-12.49.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Properly install and align motors in the locations as shown on Drawings. Use crimp-on, solderless copper terminals on the branch circuit conductors.
- B. Nameplate must be in full view when motor and equipment are installed.
- C. If a motor horsepower rating larger than indicated is offered as a substitute and is accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches, and other related items at no change in contract price.

3.2 FIELD TESTING

- A. Provide instruments, labor and personnel required to perform motor inspection and testing.
- B. Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase identification, and cleanliness. Report abnormalities to Owner's Representative before energizing.
- C. Measure full load current and full load voltage.
- D. Complete and submit Motor Test Report forms to Owner's Representative.
- E. After installation has been thoroughly checked and found to be in proper condition with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.

END OF SECTION

SECTION 23 05 19

METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes the following for hydronic piping:
 - 1. Thermometers.
 - 2. Gauges.
 - 3. Pressure and Temperature Taps.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated, submit detailed shop drawings and manufacturer's data, including:
 - 1. Measurement tolerances.
 - 2. Range.
 - 3. Accuracy.
 - 4. Device dimensions and connection sizes (include schedule indicating stem length versus pipe diameter).
 - 5. Scales.
 - 6. Materials of construction.
 - 7. Valves that will be used for isolating gauges.
- B. Submit a schedule for each device to be installed, including:
 - 1. Location.
 - 2. Pressure or temperature range of device and fluid measured.
 - 3. Temperature or pressure of fluid.
 - 4. Pipe size and bulb length of thermometers.
 - 5. Type of valve used with the Pressure Gauge.
- C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Thermometers: Calibrate against standards traceable to the NIST and guaranteed accurate to plus or minus one scale division.
- B. Pressure Gauges: ASME B40.1 Grade 2A accuracy 0.5 percent of scale range.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:
 - 1. Thermometers: Ashcroft, Dwyer, Marsh Instrument, Terrice, Weiss, Weksler
 - 2. Pressure Gauges: Ashcroft, Dwyer, Terrice, Weiss, Weksler
 - 3. Pressure/Temperature Taps: Peterson Engineering Company, Sisco or Terrice

2.2 GLASS THERMOMETERS

- A. Construction: Provide mercury free liquid in glass thermometer with a molded Valox polyester or cast aluminum case. .
- B. Window: Plastic or Glass.
- C. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- D. Scale: 9-inches long, white scale with black graduations and figures..
- E. Stem: Aluminum or Stainless steel, thermowell installation, ¼-inch diameter, minimum 3-1/2 inch straight or angle form of length to suit installation.
- F. Accuracy: Plus or minus 1 percent of full scale.
- G. Furnish thermometers for services in the following ranges and divisions:
 - 1. Chilled Water: 0 to 120 degrees F, 1 degree divisions
 - 2. Heating Hot Water: 30 to 240 degrees F, 2 degree divisions
 - 3. Condenser Water: 0 to 120 degrees F, 1 degree divisions
 - 4. Process Chilled Water: 0 to 120 degrees F, 1 degree divisions

2.3 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Brass or stainless steel with pressure and temperature ratings suitable for their application. Wells for insulated piping shall have a 2-1/2 inch lagging protrusion. Locate thermometer wells so the sensing bulb will give a true and correct reading. Install thermometer so as not to cause undue restriction in small piping. Where wells are located in pipelines 1-1/2 inch and smaller, provide a section of pipe of such diameter that the net area of the pipeline will not be reduced by the thermometer well.

2.4 PRESSURE GAUGES

- A. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Liquid-filled type, polypropylene case, 4-1/2 inch diameter, solid front with blow-out back.
 - 2. Bourdon Tube: Bronze or 316 stainless steel with brass or stainless steel socket.
 - 3. Movement: 300 series stainless steel rotary type with stainless steel bushings
 - 4. Dial: White face with black figure.
 - 5. Pointer: Red or black, micro adjustable.
 - 6. Window: Molded Acrylic.
 - 7. Ring: Metal.
 - 8. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
 - 9. Gauge Ranges
 - a. Provide 0 - 160 psi gauges for 150 psi chilled/hot water service.
- B. Pressure-Gauge Fittings:
 - 1. Valves: NPS 1/4 brass or stainless-steel needle type.
 - 2. Siphons: NPS 1/4 coil of brass or stainless steel tubing with threaded ends.

3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.5 PRESSURE AND TEMPERATURE TAPS:

- A. Taps. Provide 1/2" solid brass fittings which will receive either a pressure or temperature probe, with valve core of Nordel and fitted with a color coded cap and gasket. P/T Taps shall be rated for 275 degrees F. and 1000 psig. Provide long stem type for insulated pipe.
- B. Instruments. Provide two each, No. 500 "Pete's Plug" pressure gauge adapters with four gauges and probes and four each 5" stem pocket thermometers: Two each, thermometers for chilled water, heating and domestic hot water systems, when applicable. Applicable meaning the system is being installed as part of the project. "Pete's Plugs" to match insulation thickness.

PART 3 - EXECUTION

3.1 THERMOMETER INSTALLATIONS

- A. Provide thermometers and thermometer wells in the following locations:
 1. As shown on Drawings and control schematics.
- B. Install direct-mounting thermometers and adjust vertical and tilted positions.
- C. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees where thermometers are indicated.

3.2 GAUGE INSTALLATIONS

- A. Provide pressure gauges in the following locations:
 1. Supply and return piping connections of coils (where shown on details).
 2. As shown on Drawings and control schematics.
- B. Install direct-mounting pressure gauges in piping tees with pressure gauge located on pipe at most readable position.
- C. Install needle-valve in piping for each pressure gauge for fluids.
- D. Install snubber for gauges associated with pumps.
- E. Provide fittings as necessary to install pressure gauge in the vertical position.

3.3 PRESSURE AND TEMPERATURE TAP INSTALLATIONS

- A. Provide pressure and temperature taps at the following locations:
 1. Inlet and outlet of each coil connection.
 2. Inlet and outlet of each hydronic control valve
 3. Where shown in details on mechanical drawings.

3.4 CONNECTIONS

- A. Install thermometers and gauges adjacent to machines and equipment to allow service and maintenance for thermometers, gauges, machines, and equipment. Thermometer

3.5 ADJUSTING

- A. Adjust faces of meters and gauges to proper angle for best visibility.

END OF SECTION

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for furnishing and installing chilled water piping , condensate piping valves and appurtenances, including fittings and strainers.
- B. Related Sections:
 - 1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
 - 2. Section 23 05 53, Identification for HVAC Piping and Equipment, for valve tags and schedules.

1.2 SUBMITTALS

- A. Product Data: Submit manufacturer's product data showing compliance with requirements of Part 2. Clearly indicate piping, equipment, materials of construction, pressure rating and which options are to be provided.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Protect all piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions.
- B. Piping shall be sent from the factory with capped ends and shall be stored on supports off of the ground with ends covered to prevent nesting of insects, birds and other animals, or the accumulation of dirt and debris in and around the piping components.

1.4 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Provide only domestically manufactured piping and fittings.
- B. Refer to HVAC valve schedule articles for applications of valves.
- C. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- D. Valve Sizes: Same as upstream piping unless otherwise indicated.

- E. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
 - 2. Handwheel: For valves other than quarter-turn types.
 - 3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
 - 4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

- F. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
 - 1. Ball Valves: Provide an insulated stem extension.
 - 2. Butterfly Valves: With extended neck.

- G. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Solder Joint: With sockets according to ASME B16.18.
 - 3. Threaded: With threads according to ASME B1.20.1.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Check Valves: Apco, Crane, Kitz, Mission, Milwaukee, Mueller, Nibco, Powell, Stockham and Weco.
 - 2. Plug Valves: DeZurik, Keystone, Mueller, or Stockham.
 - 3. Globe Valves: Crane, Kitz, Milwaukee, Nibco, Powell, or Stockham.
 - 4. Butterfly Valves: Bray, Clow, Demco, DeZurik, Crane, Kitz, Milwaukee, Nibco, Pratt, or Stockham.
 - 5. Ball Valve: Apollo, Crane, DeZurik, Kitz, Milwaukee, Nibco, or Watts.
 - 6. Strainers: Armstrong, Keckley, Mueller Spirax or Watts.
 - 7. Coil Packs: IMI Hydronic Engineering Inc., Nexus, Nibco, Pro Hydronic Specialties.

2.3 CHECK VALVES

- A. For pipe 2 inches in diameter and smaller, furnish 150-pound (class 150) screwed, horizontal, swing check valve, all bronze construction, with screwed cap.

2.4 PLUG VALVES

- A. For pipe 2 inches in diameter and smaller, use 150-pound (class 150) screwed, eccentric plug valve with a bronze body, bolted bonnet, Fluorinated Hydrocarbon (Viton) Filled PTFE packing, Isobutene-Isoprene or Viton faced plug, stainless steel bearings, lever operated with adjustable memory stop, non-lubricated, short pattern plug valve.

2.5 GLOBE VALVES

- A. For pipe 2 inches in diameter and smaller, provide 150-pound (class 150) screwed, rising stem, globe valve with bronze body, TFE disc, union bonnet.

2.6 BALL VALVES

- A. For pipe 2 inches in diameter and smaller, provide 600 psi WOG screwed, two piece bronze or forged brass body, Teflon seat, full port, stainless steel stem and ball. Provide

extension stem and insulated handle for valves installed in insulated piping. Where ball valves are used as balancing valves, provide valve with memory stop.

2.7 STRAINERS

- A. For pipe 2 inches in diameter and smaller, use 125-pound (class 125) cast bronze screwed Y-type strainer with 12-mesh stainless steel screen. Provide full size blowoff ball valve where shown on drawings.

2.8 VALVES FOR FAN COIL UNITS AND TERMINAL BOXES (COIL PACK)

- A. General. The following products are for terminal boxes and fan coil units with pipe sizes 2-inches and less.
- B. Combination Ball Valve w/PT Test Port and Strainer w/blowdown valve. Provide dezincification resistant or forged brass construction, 600-pound, 325F construction with multiple ¼" tapped ports for test plugs or other accessories and union end. Valve shall have blowout proof stem with stainless steel ball. Strainer shall have 20 mesh Type 304 stainless steel screen and ¾" hose bib & cap.
- C. Combination Ball Valve w/Memory Stop and PT Test Port. Provide dezincification resistant or forged brass construction, 600-pound, 325F construction with multiple ¼" tapped ports for test plugs or other accessories and union end. Valve shall have blowout proof stem with stainless steel ball.
- D. Combination PT Test Port w/Manual Air Vent. Provide dezincification resistant or forged brass construction, 600-pound, 325F construction with multiple ¼" tapped ports for test plugs or other accessories and union end.
- E. PT Test Ports. Shall be rated for 1000 psi, 325F with brass body, Nordel check plugs and sealed cap.
- F. Stainless Steel Flex Hoses. Shall be designed for water and conform to ASTM codes E84, with stainless steel outer braid. Hoses 1/2-inch thru 1-inch shall have a Kevlar reinforced EPDM tube core, brass end fittings, and designed for a working pressure of 400 psi, 248F. Hoses 1¼-inches thru 2-inches shall have Rayon reinforced EPDM tube core, brass end fittings, and designed for a working pressure of 300 psi, 248F. All hoses shall have at least one union or swivel end fitting and be maximum 18-inches in length.
- G. Manual Air Vents. Shall be of brass construction and rated at 400 psi, 325F.
- H. Shaft extensions (2" and smaller). For insulated pipe shall be at least 2¼" tall and constructed of brass with a stationary external shaft housing to ensure vapor barrier seal.

PART 3 - EXECUTION

3.1 STORAGE:

- A. Protect all piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions. All piping shall be sent from the factory with capped ends and shall be stored on supports off of the ground with ends covered to prevent

nesting of insects, birds and other animals, or the accumulation of dirt and debris in and around the piping components.

3.2 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.3 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Provide clearance for access to valves, fittings and equipment for operation and maintenance.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement and with operators and stems upright or horizontal.
- F. Install chainwheels on operators for butterfly gate and globe valves NPS 4 and larger and more than 84 inches above floor. Extend chains to 60 inches above finished floor.
- G. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.
- H. All piping shall be clean when it is installed.
- I. Check Valves. Install lugged check valves between flat flange and full-face gasket. Install check valves a minimum three to four pipe diameters downstream of pump discharge or elbows to avoid flow turbulence.

3.4 ISOLATION VALVES

- A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving equipment, and at other locations as indicated and required for isolation of piping or equipment.

3.5 DRAIN VALVES AND VENTS

- A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained.
- B. Install 2 inch drain for 2 inch pipes and larger.
- C. Install a line size drain valve for pipes smaller than 2 inches.
- D. Provide hose adapter and cap on all drain lines.
- E. Provide automatic vents with isolation valves or manual vents at locations as indicated on Drawings and all high points in piping systems.

3.6 TESTING

- A. Apply a hydraulic pressure 1-1/2 times the operating pressure, 150-psig minimum, and carefully check for leaks.
- B. Remove or isolate valves, expansion joints, strainers and equipment that are rated at pressures less than test pressure.
- C. Repair all leaks and retest the system until proven leak tight.

3.7 ADJUSTING

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

END OF SECTION

SECTION 23 0531 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for furnishing and installing supports, anchors, hangers, sleeves, and concrete equipment pads for all direct and isolated suspended, roof mounted, and floor mounted HVAC equipment and exterior pipe and ductwork.
- B. See Division 05 Section, Metal Fabrications, for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
- C. See Section 23 05 48, Vibration and Seismic Controls for HVAC Piping and Equipment, for vibration isolation devices.
- D. See Section 23 31 13, Ductwork, for duct hangers and supports.

1.2 DEFINITIONS

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

1.3 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's catalog data, dimensional drawings and construction materials for the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Equipment supports.
- C. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver all roof support material materials to project site in manufacturer's original packaging, marked with manufacturer's name, product model names and catalog numbers, identification numbers, and other related information.
- B. Store material under cover until needed for installation

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers as applicable:
 - 1. Anvil Intl., Inc.
 - 2. Superstrut, Mult-A-Frame, Unistrut and Power-Strut pipe support systems
 - 3. Specified Technologies, Inc.
 - 4. Pipe Shields, Inc.

2.2 CONCRETE

- A. Provide minimum 3,000 psi concrete. Reinforce slab with minimum No. 4 rebar on 12-inch centers each way, centered in slab unless otherwise indicated on Drawings.

2.3 STRUCTURAL METAL

- A. Furnish structural metal as specified in Division 05 and as shown on Drawings.

2.4 PIPE HANGERS AND SUPPORTS

- A. Provide hangers for insulated and non-insulated pipes, provide galvanized carbon steel adjustable clevis hangers. Anvil Fig. 260 or equal.
- B. Multiple Hot Pipes and insulated cold pipes supported by a trapeze hanger, provide cast iron roll with galvanized finish cast iron roll beneath each pipe.
- C. Multiple or Trapeze Hangers: Provide Galvanized steel channels with welded spaces and hanger rods; cast iron roll with galvanized finish and stand for sizes 4 inches and large for heating and chilled water piping.
- D. Wall supports: Provide galvanized welded steel brackets and galvanized wrought steel clamp, galvanized adjustable steel yoke and cast iron roll. Anvil Fig. 194, 195, 199 as required by pipe size and weight. Submit to structural engineer for approval detailing method of attachment to wall.
- E. Vertical Support: Provide galvanized riser clamp with field welded shear lugs. Anvil Fig 261 or Fig 40 as required by installation and loads to be supported. Refer to mechanical details for main riser supports.
- F. Floor supports for Pipe sizes to 4 inches and all cold pipe sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange and steel support. Anvil Figures 264 or 265 as required.

- G. Floor supports for Hot pipe 6 inches and larger: Provide adjustable cast iron roll and stand, adjusting screws and steel support all galvanized. Anvil Fig. 274.
- H. Copper Piping Supports and Hangers: Provide copper plated carbon steel clevis hanger. Anvil Fig. Anvil CT-65.
- I. Provide galvanized hangers and supports for all piping and ductwork located in crawlspaces, pipe shafts and chases and above suspended ceiling spaces.
 - 1. Provide hanger rods, bolts and nuts and all metal parts coated with same material as hangers.
 - 2. Prime coat and paint exposed steel hangers and supports.

2.5 PIPE SHIELDS

- A. Provide pipe shields for piping 2 inches and smaller fabricated of 20 gauge galvanized steel over insulation in 180 degree segments, minimum 12-inches long.
- B. Provide pipe shields for piping 2-1/2 inches and larger fabricated of galvanized steel over insulation in 180 degree segment as follows:

PIPE SIZE	METAL GAUGE	SHIELD LENGTH
2-1/2 to 6 inches	18	12 inches
8 to 16 inches	16	18 inches
18 inches and larger	12	24 inches

- C. Provide high density segment of insulation at shields at least two inches longer than shield. Foamglas blocks (HLB 1600) or factory made insulation shields as made by Pipe Shields, Inc. are acceptable. High density insulation segment shall be of sufficient compressive strength to prevent indentation of insulation jacket. Submit data indicating compressive strength of insulation segment. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).
- D. Secure insulation shields to insulation jacket with adhesive as recommended by insulation manufacturer or 2 stainless steel bands, 1/2 inch wide by 0.015 inch thick with matching seals.

2.6 HANGER RODS

- A. Provide cadmium plated steel, threaded both ends continuous sized for supported load.

2.7 INSERTS

- A. Provide malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded rods. Submit data to structural engineer for approval. Anvil Fig. 282.

2.8 SLEEVES

- A. Fit with sleeves all pipes passing through gyp board, masonry and concrete construction. Provide sleeves in floors and walls of mechanical rooms, pump rooms, etc. constructed of schedule 40 steel with galvanized finish. Sleeves outside mechanical room type spaces shall be galvanized EMT conduit for 2 inch diameter sleeves. Sleeves outside

mechanical room type spaces over 2 inch and thru walls shall be rolled 20 gauge galvanized steel with welded seam. All galvanizing shall be done after welding.

- B. Sleeves in floors shall be provided with a 1-1/2 inches wide center flange welded to sleeve and centered in slab. Refer to Drawings for additional requirements.
- C. Sleeves thru roofs: schedule 40 galvanized steel pipe.
- D. Caulk all sleeves water and air tight. Provide firestop compound at all penetrations of floor slabs and fire rated walls.
- E. Sleeves below grade in outside walls are detailed on drawings. Provide Link Seal casings at sleeves at all exterior walls above and below grade. Use stainless steel retainers, nuts and bolts in sleeves below grade. Size sleeves in accord with Link Seal recommendations.
- F. Size sleeves one pipe size larger than the pipe it serves including insulation thickness as appropriate.
- G. Extend each sleeve through the floor or wall. Cut the sleeve 1/2 inch beyond flush from each surface, except that in exposed locations, extend floor sleeves 2 inches above finished floor line.

2.9 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections for piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use copper hangers with copper pipe and nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing. As an alternate, tape copper pipe at all points contacting steel hangers, structural members or sleeves. Use a dual wrap of polyvinyl tape.
- E. Use padded hangers for piping that is subject to scratching.

3.2 PIPE HANGER AND SUPPORT INSTALLATION

- A. Support horizontal steel piping on center as follows:

PIPE SIZE	MAX HANGER SPACING
1/2 to 1-1/4 inches	6 feet
1-1/2 to 2 inches	10 feet
2-1/2 to 6 inches	10 feet
6 to 12 inches	10 feet
14 inches and larger	10 feet

- B. Place a hanger within 6 inches of each elbow.
- C. Provide hangers with vertical adjustment of 1-1/2 inches minimum.
- D. For copper piping up to 1-inch place hangers not more than 5 feet apart, for 1-1/4 inch to 1-1/2 inch piping, place hangers not more than 7 feet – 0 inch apart and for 2-inch to 3-inch piping not more that 9 feet 0 inches apart.
- E. Larger Sizes: Support as recommended by manufacturer.
- F. Submit manufacturer's support and hanging recommendations.
- G. Support piping from structure independent from other piping installed above.
- H. Support risers as detailed on drawings at each floor and independently from connected horizontal pipe.
- I. Where insulation occurs, design hangers to protect insulation from damage. Pipe saddles and insulation shields, where required, are specified above.
- J. Perforated bar hangers, straps, wires or chains are not permitted.
- K. Support piping from precast and pan joist structure as detailed on drawings.
- L. Powder actuated anchors are not permitted.
- M. Sleeves penetrating beams must be submitted for approval by Structural Engineer.

3.3 CONCRETE PADS

- A. Pour 6-inch pads on roughened floor slabs unless otherwise noted.
- B. Extend outer edges of pads minimum 2 inches beyond equipment.
- C. Chamfer edges of pads.
- D. Secure equipment with anchor bolts in accordance with equipment installation instructions.
- E. Air handling units shall be installed on concrete pads with adequately sized neoprene isolation pads at each air unit support point.

- F. Verify that housekeeping pads for air handling units are high enough to provide a condensate drain trap deep enough to override the air handler static pressure.
- G. Install pump inertia bases on 6 inch pads.
- H. Install expansion tanks on 6 inch pads.

3.4 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Bolt floor stands to 4 inch thick concrete pads or as shown on Drawings.
- C. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- D. Provide lateral bracing, to prevent swaying, for equipment supports.
- E. Hot dip galvanize after fabrication.

3.5 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Hot dip galvanize after fabrication.
- D. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

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

3.7 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 23 05 48

VIBRATION ISOLATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes requirements for furnishing, installing, and adjusting vibration isolation, for mechanical equipment and piping, including bases of structural steel and concrete, with steel pouring forms and concrete reinforcing bars.
- B. Related Sections Include:
 - 1. Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.
 - 2. Section 23 21 13, Hydronic Piping and Fittings.
 - 3. Section 23 34 13, Fans.

1.2 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 - 1. Basic Wind Speed: 125 miles per hour.
 - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.3 SUBMITTALS

- A. Product Data: Submit product data showing type, size, load, deflection, and other required information. Include clearly outlined procedures for installing and adjusting isolators. Submit Drawings for each item of equipment with complete isolation installation information.
- B. Submit detailing of inertia bases and locations of vibration, including weight of inertia base.

1.4 QUALITY ASSURANCE

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

1.5 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Include copies of approved submittals and any submittal comments.
- C. Provide tab for each major type of equipment (fan coil units, pumps, piping, fans, etc.). Provide schedule of vibration isolator type with location and load on each. Include data on each isolator type that corresponds to:
 - 1. Spring diameter.
 - 2. Deflection.
 - 3. Compressed spring height.
 - 4. Point location of each isolator.

5. Calculated load at each point.
 6. Field static deflection.
- D. Include copy of written certification from factory representative as required in Part 3 of this specification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
 2. Kinetics Noise Control
 3. Korfund Dynamics
 4. Mason Industries.
 5. Metraflex
 6. Vibration Eliminator Co., Inc.

2.2 ISOLATOR DESIGN

- A. Materials:
1. Design and treat vibration isolators for resistance to corrosion.
 2. Steel components shall be PVC coated or phosphatized and painted with industrial-grade, corrosion-resistant enamel.
 3. Furnish zinc-electroplated or cadmium plated nuts, bolts and washers.
 4. All isolators exposed to the weather shall have the steel parts hot dip galvanized and a PVC coating.
 5. Clean steel bases thoroughly of welding slag and prime with zinc-chromate or metal etching primer.
- B. Design:
1. Unless otherwise instructed, use spring-type vibration isolators for all equipment driven by motors of 3 horsepower and larger.
 2. The isolator manufacturer must calculate the amount of spring deflection required for each isolator to achieve optimum performance and to prevent the transmission of objectionable vibration and noise.
 3. Isolators must be sized for starting torque of equipment motors.
 4. The following minimum spring deflections apply unless noted otherwise in the specifications:

BELT DRIVEN EQUIPMENT

Motor Size Horsepower	Installation Above Grade	Installation at Grade or Below
5 – 10	1"	1"
15 – 30	1-1/2"	1"
40 – 75	2"	1-1/2"

DIRECT DRIVEN EQUIPMENT

Motor Size Horsepower	Installation Above Grade	Installation at Grade or Below
5 – 20	1"	1"
25 – 75	1"	1"

5. All spring isolators must be completely stable in operation and must be designed for not less than 30 percent reserve deflection beyond actual operation conditions.
6. Height saving brackets used with isolators having 2-1/2 inch deflection or greater shall be of the precompression type to limit exposed bolt length.

2.3 ISOLATOR TYPES

- A. Design of isolator types listed is based on model numbers manufactured by Kinetics Noise Control, unless otherwise indicated. Subject to compliance with requirements provide named product.
- B. Type SRH: Combination spring and rubber hanger consisting of a rectangular steel box, coil spring, spring retainers, and an elastomeric mounting designed for 1/2 inch deflection.
- C. Type NGS: Pad-type mounting consisting of two layers of 3/8 inch thick ribbed or waffled neoprene pads bonded to a 16-gage galvanized steel separator plate. Size pads for approximately 20 to 40 psi load and a deflection of 0.1 inch to 0.16 inch.
- D. Type SS: Type 321 stainless steel hose and Type 304 stainless braid sheath, with carbon steel threaded fittings for pipe sizes 2 inches and less, and carbon steel flanges for pipe sizes 2-1/2 inches and greater. Hose shall have a maximum working pressure of 200 psi at 70°F through 4", 155 psi at 70°F through 12".

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.
- D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
- E. Install motor driven equipment with vibration isolators as indicated in schedule below.

- F. Isolate pumped water-piping systems with spring-type vibration isolators as indicated in schedule.
- G. All open-type spring isolators shall be restrained as recommended by the manufacturer.
- H. Install full line size flexible connectors at the suction and discharge connection of each piece of equipment as indicated in schedule below. All connectors to be suitable for use at the pressure and temperature encountered at point of operation. Do not insulate Type REJ flex pump connectors installed in heating hot water systems.

3.2 APPLICATION

- A. The following is a schedule of equipment and piping on a typical project that requires vibration isolation and base isolators of the types specified. Refer to Drawings for equipment scheduled for the Project. Any equipment, system or condition that may be altered, added, or changed; or that is not specifically described in the Contract Documents shall be isolated in a manner specified for similar equipment, system or condition in order to comply with these Specifications.
- B. Provide isolation for the following equipment:

Equipment	Isolator Type	Minimum Deflection (inches)
Fan Coil Units:		
Suspended	SRH	1
Belt Drive - Suspended	SRH	1
Floor Mounted	NGS	0.1 – 0.16

3.3 STOCK REQUIREMENTS

- A. The isolation manufacturer's representative must maintain an adequate stock of springs and isolators of type used so that changes required during construction and installation can be made.

3.4 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.5 FACTORY REPRESENTATION:

- A. After installation, furnish factory-trained representative of the isolation manufacturer to check various isolators and report measured versus anticipated deflection on all isolators. Have the representative submit written certification that the isolators have been installed in accordance with the specifications, manufacturer's recommendations and approved submittals

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.
 - 7. Duct labels.

1.2 SUBMITTAL

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

1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.4 RELATED WORK

- A. Painting. Division 09.

1.5 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Valve Tags
 - 1. Provide three-ring binder including valve tag information (8-1/2 x 11 inch paper).
 - 2. Each service shall be individually tabbed in the binder.
 - 3. For each valve tag, indicate service, function, valve position (NC or NO), floor, room location and nearest column numbers.

- C. Equipment Labels
 - 1. Provide three ring binder including equipment label information (8-1/2 x 11 inch paper).
 - 2. Each type of equipment (pumps, AHUs, etc) shall be individually tabbed in the binder.
 - 3. For each item of equipment to be labeled, provide equipment identification number, floor, room location, and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufactures: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Marking Services, Inc.
 - 3. Seton Identification Products.

2.2 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, 0.032 inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 x 3/4 inch.
 - 3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 4. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Black.
 - 3. Background Color: Background to contrast with letter color.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160°F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 inch x 3/4 inch.
 - 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number.

2.3 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: Background to contrast with letter color.
- D. Maximum Temperature: Able to withstand temperatures up to 160°F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 inch x 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering 2/3 to 3/4 the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.4 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used in the existing facility, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.5 PIPE STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
 - 1. Paint: Standardized colors and meet VOC requirements per Division 09 painting specification. Subject to compliance with requirements, provide named color or comparable product as approved. Use the following colors for banding of all piping:

SYSTEM	COLOR
--------	-------

Chilled and/or Heating Water	Match existing colors within facility
Drain Lines	Match existing colors within facility
Other Piping Systems	Match existing colors within facility

2. Standardized Sizes: Tags shall be at least 1-1/2 inches in diameter, with depressed block characters 1/4 inch high. Titles shall be lettered on bands. Uppercase letters and Arabic numerals shall be used. Where pipes or conduits are too small or not readily accessible for such application securely fasten a brass identification tag at appropriate locations. Identification of the material contained in piping and conduits in accordance with the table below:

BAND AND LETTER SIZE ALL DIMENSIONS IN INCHES		
Outside Diameter of Pipe Covering	Width of Color Band	Size of Letters and Numerals
1/2 to 1-1/4	8	1/2
1-1/2 to 2	8	3/4
2-1/4 to 3-1/4	10	1

3. Pipe Identification: Identify pipe at wall penetrations, machine or tank connections, and at not over 50 foot intervals. Marker identification should be visible from the floor. Mark each pipe circuit with stencil. Stencil shall include flow arrow and identification marks as follows:

SERVICE	MARK
Chilled Water Supply (air conditioning)	Match existing marks
Chilled Water Return (air conditioning)	Match existing marks

2.6 DUCT LABELS

- A. Identify ductwork with stencil.
- B. Letter Color: Black.
- C. Lettering Size: At least 1-1/2 inches high.

- D. Paint: Shall meet VOC requirements per Division 09 painting specification.
- E. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

2.7 VALVE TAGS

- A. Provide valves with 1 1/2 inch diameter stainless steel or brass valve tag with stamped and black-filled numbers. Service designations shall be 1/4 inch letters, and valve numbers shall be 1/2 inch letters. Service designations shall be approved by Architect/Engineer. Secure tags to valves by use of brass "S" hooks and brass chain. Secure chain to valve by use of copper or monel meter seals.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment. Use fasteners for all equipment labels where possible. Where it is not possible to use fasteners, use adhesive.
- B. Locate equipment labels where accessible and visible.

3.3 VALVE TAG

- A. Install valve tags for all major valves. This shall include branch isolation and balancing valves, isolation valves for equipment such as air handling units, pumps, chillers, etc.
- B. Do not provide valve tags for isolation valves directly adjacent to fan coil units and terminal boxes.

3.4 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 7. Do not label drain piping where the floor drain is located adjacent to the equipment.

- B. Provide pipe labels for the following piping systems:
 - 1. Chilled Water Systems
 - 2. Drain lines

3.5 DUCT LABEL INSTALLATION

- A. Identify ductwork with stencil.
- B. Identify exhaust fan number, air handling unit number, service and area served.
- C. Locate identification at air handling unit or fan, at each side of penetration of structure or enclosure at each obstruction, every 20 feet on long horizontal runs. Provide identification for the following ductwork:
 - 1. All exhaust (restroom, laboratory, kitchen, etc) and relief ductwork.
 - 2. All supply air ductwork served by Air Handling Units
 - 3. All outside air ductwork, including pretreated outside air ducts.
 - 4. All return air ductwork, not including return air boots and transfer ducts.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. The Bidding and Contract Requirements and General Requirements apply to this work.
- B. All Division 21, 22, 23 Sections apply to this work.
- C. Section 23 08 00, Commissioning of HVAC Systems

1.2 SCOPE OF WORK

- A. Testing, adjusting, and balancing (TAB) of the air conditioning systems, related ancillary equipment and domestic water system will be performed by an impartial technical TAB firm selected and employed by the Owner.
- B. As a part of this Contract, the Contractor and/or Mechanical Subcontractor shall make any changes in the sheaves, belts, dampers, valves, etc. required for correct balance as required by the TAB firm, at no additional cost to the Owner.
- C. The Contractor shall ship terminal boxes to the TAB firm for leak testing in his shop prior to installation. Refer to Section 23 37 13, Air Devices.
- D. The Mechanical Subcontractor shall provide and coordinate services of qualified, responsible subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the testing, adjusting and balancing period.
- E. In order that all systems may be properly tested, balanced, and adjusted as required herein by these Sections, the Contractor shall start-up and check-out all systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB. This length of time shall be acceptable to the Owner's Representative.
- F. Contract completion schedules shall provide sufficient time to permit the completion of TAB services prior to Owner occupancy.
- G. The Drawings and Specifications have indicated valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor or the Inspector shall be corrected by the Contractor immediately so the balancing work can proceed.
- H. Contractor must insure that the necessary systems are scheduled to be in operation for TAB firm so that the access for balancing to diffusers, dampers etc., is not restricted. Contractor must schedule and coordinate activities so that TAB firm is not restricted from performing work, including access to damper operators and air devices.

- I. The Contractor shall correct deficiencies in a timely manner and produce a signed copy of the deficiency lists to the Owner. At that time, the TAB firm will return and verify that the deficiencies are corrected.

1.3 MATERIALS AND WORKMANSHIP

- A. The scope of the TAB work as defined herein is indicated in order that the Contractor and/or Mechanical Subcontractor will be apprised of the coordination, adjustment, and system modification which will be required under the project work in order to complete the Owner's requirements for final TAB.
- B. The TAB firm will not have a contractual relationship with this Contractor but will be responsible to the Owner's Representative for the satisfactory execution of the TAB work. The Contractor shall allow sufficient funds in the project cost estimate and bid proposal to cover all work which may be required in the TAB phases as defined herein and as may be necessary for the completion of the TAB work as defined by the TAB firm.

1.4 RESPONSIBILITY OF CONTRACTOR

- A. The Contractor shall have the building and air conditioning systems in complete operational readiness and shall perform all other items as described hereinafter to assist the TAB Firm in performing the balancing, testing, and adjusting of the air and hydronic systems. He shall promptly correct deficiencies of material and workmanship identified as delaying completion of TAB work. The items shall include the following.
 1. Air Distribution Systems:
 - a. Verify installation for conformity to design. All supply, return and exhaust ducts terminated.
 - b. All volume, splitter, extractor and fire dampers properly located and functional. Dampers shall provide tight closure and full opening, smooth and free operation.
 - c. All supply, return, exhaust, transfer grilles, registers, diffusers, and terminal units installed, leak tested and operational.
 - d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be blanked and/or sealed to eliminate excessively by-pass or leakage of air.
 - e. All fans (supply, return, relief and exhaust) operating and verified for freedom from vibration, proper fan rotation and belt tension; overload heater elements to be of proper size and rating; and clean filters installed.
 2. Water Circulating Systems:
 - a. Water systems shall be cleaned by circulation and strainers cleaned for normal operation.
 - b. Verify electrical overload heater elements to be of proper size and ratings.
 - c. All water circulating systems shall be full and free of air; all vents installed at high points of systems.
 3. All controlling instruments calibrated and set for design conditions.
- B. Tabulated Data. The motor amperages, voltages and overload heater size of each piece of electrically driven equipment, including exhaust fans, shall be recorded showing "actual" and "nameplate" data and submit to the owner prior to balancing.
- C. The Contractor and the suppliers of the equipment installed shall all cooperate with the TAB Firm to provide all necessary data on the design and proper application of the system components and shall furnish all labor and material required to eliminate any

- deficiencies or malperformance. Furnish a list of all motors with nameplate data and size of overload heater installed with motor amperage during operation.
- D. During the balancing the temperature regulation shall be adjusted for proper relationship between controlling instruments and calibrated by the Control Manufacturer using data submitted by the TAB Firm.
 - E. In all fans systems, the air quantities shown on the plans may be varied as required to secure a maximum temperature variation of 2 degrees within each separately controlled space, but the total air quantity indicated for each zone must be obtained. It shall be the obligation of the Contractor to furnish or revise fan drives, sheaves, belts, dampers, etc., and/or motors if necessary, without cost to the Owner, to attain the specified air volumes.
 - F. The Contractor shall assist the TAB Firm in performing 3 inspections within 90 days after occupancy of the building to ensure that satisfactory conditions are being maintained throughout and to satisfy any unusual condition.

1.5 RESPONSIBILITY OF TAB FIRM

- A. The services of balancing, testing, and adjusting of the heating, ventilating, and air conditioning systems, will be performed by an independent technical firm or balancing company operating under the same firm name for five years with a minimum of five years specialized experience in the field of air conditioning system balancing, and possessing calibrated instruments, qualified Engineers, and skilled technicians to perform all required tests.
- B. The TAB personnel shall check, adjust, and balance the components of the air conditioning system including which will result in optimum noise, temperature, and air flow conditions in the conditioned spaces of the building while the equipment for the system is operating economically. Equipment to be tested includes, but is not limited to, all air handling units, fan coil units, terminal boxes, air devices, pumps, and exhaust fans. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents, which is the responsibility of the project contractor. Variable air volume systems shall be balanced in accordance with AABC Manual #MN-7 "Variable Volume System Standards."
- C. The tests shall demonstrate the specified capacities and operation of all equipment and materials comprising the systems. Such tests shall be made as are deemed necessary by the Architect indicate the fulfillment of the contract. The TAB Firm shall then make available to the Architect such instruments and technicians as are required for spot checks of the systems.
- D. The TAB Firm will not instruct or direct the Contractor in any of the work. Any proposed changes or revisions in the work shall be submitted to the Architect/Owner in writing. The Architect/Owner will process the proposal as appropriate.
- E. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the owner shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal, but must be understandable and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report. The TAB firm shall not instruct or direct the Contractor in any of the work, but will make such reports as are necessary to the Owner.

- F. Coordinate as required with Commissioning Agent. Refer to Specification 23 08 00.

1.6 BALANCING SERVICES

- A. The TAB Firm, Architect/Engineer and Owner will inspect the installation of heating and cooling pipe systems, sheet metal work, temperature and other component parts of the heating, air conditioning, and ventilating systems. The inspection of the work will cover that part relating to proper arrangement and adequate provisions for the testing and balancing. The inspections shall be performed periodically as the work progresses.
- B. Upon formal notification of completion of the installation and start-up of the mechanical equipment by the Contractor, the TAB Firm will balance, test, and adjust the systemic components to obtain optimum conditions in each conditioned space in the building.
- C. The TAB Firm shall be responsible for inspecting, balancing, adjusting, testing, and logging the data on the performance of fans, all dampers in the duct systems, all air distribution devices, and the flows of water through all coils.
- D. Final Air Balance. When systems are complete and ready for operation, the TAB Consultant will perform a final air balance for all air systems and record the results. The outside, supply, exhaust and return air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within +5% of the value shown on the drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. Air distribution device volume shall be adjusted using the spin-in tap damper for flexible duct connected devices and the device OBD for duct connected devices. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The general scope of balancing by the TAB Consultant will include, but is not limited to, the following:
1. Filters: Check air filters and filter media and balance only system with essentially clean filters and filter media. The Division 23 Contractor shall install new filters and filter media prior to the final air balance.
 2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required make any required changes.
 3. Ampere Readings: Measure and record full load amperes for motors.
 4. Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. Static pressure readings shall also be provided for systems which do not perform as designed.
 5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM (s) and temperatures, as applicable, at each fan, blower and coil.
 6. Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).
 7. Zone Air Flow: Adjust each zone of multizone units, each HVAC terminal unit and air handling unit for design CFM.
 8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within +5% of design air CFM. Include all terminal points of air supply and all points of exhaust.

9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all exhaust ducts, main supply ducts, return ducts and airflow measuring stations shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.
 10. Maximum and minimum air flow on terminal boxes.
- E. Final Chilled Water Balance. When systems are completed and ready for operation, the TAB Consultant will perform a final water balance for each chilled water system. The general scope of balancing by the TAB Consultant will include, but not be limited to, the following:
1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger for design flow, +5%. Adjust balancing valves at pumps to obtain design water flow. Permanently mark the balanced position for each valve.
 2. Temperature Readings: Read and record entering and leaving water temperatures at each water coil. Adjust as necessary to secure design and conditions. Provide final readings at all thermometer well locations.
 3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler. The flow of water through all water coils shall be adjusted by manipulating valves until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. For coils equipped with 3 way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.
 4. Ampere Readings: Reading and record full load amperes for each pump motor.
- F. Testing Of Temperature Control Systems. In the process of performing the TAB work, the TAB Agency shall:
1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
 2. Verify that all control devices are properly connected.
 3. Verify that all dampers, valves and other controlled devices are operated by the intended controller.
 4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
 5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes dampers in multizone units, terminal boxes, and fire/smoke dampers.
 6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
 7. Observe the calibration of all controllers.
 8. Verify the proper application of all normally opened and normally closed valves.
 9. Observe the locations of all temperature sensors, carbon dioxide sensors and humidity sensors for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
 10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Control Contractor will relocate as deemed necessary by the TAB Agency.
 11. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and specifications. Verify that no simultaneous heating and cooling occurs.

12. Verify that all controller setpoints meet the design intent.
 13. Check all dampers for free travel.
 14. Verify the operation of all interlock systems.
 15. Perform variable volume system verification to assure the system and its components track with changes from full flow to minimum flow.
 16. A systematic listing of the above testing and verification shall be included in the final TAB report.
- G. The TAB Firm will, fourteen (14) days prior to Final Air Balance Inspection, prepare an electronic copy (pdf) of the completed Test and Balance Report. The Report shall be complete with logs, data, and records as required herein and all logs, data, and records shall be typed, produced on white bond paper, and bound with staples and tape. The Report shall be certified and approved by the professional principle Engineer of the TAB Firm and his seal shall appear on the first page of the report. Transmit one (1) copy direct to the Owner's Representative and one (1) copy to the Architect. The Architect will review and approve the report. Upon approval, submit a copy (pdf to the Owner's Representative and the Contractor.

1.7 STANDARDS

- A. The TAB Firm shall perform the services in accordance with the Associated Air Balance Council's (AABC) standards and procedures including revisions to the date of the contract.

1.8 STORAGE

- A. Refer to Mechanical General Provisions. The Contractor shall provide the TAB Firm an area of ample size, conveniently located for storage of tools, equipment, and other items as required.

1.9 NOTIFICATION

- A. Systems shall be complete and in operational readiness prior to notifying the Owner that the project is ready for the services of the TAB Firm and the Contractor shall so certify in writing to the Owner that such a condition exists. Systems shall be complete and in operational readiness prior to notifying the Owner that the project is ready for the services of the TAB Firm and the Contractor shall so certify in writing to the Owner that such a condition exists.
- B. Should the Owner be not notified and the TAB work commenced and the systems are found to not be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by the Owner. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services. Should the inspection reveal the notification to have been premature, all costs of the inspection and work previously accomplished by the TAB Firm shall be paid for by the Contractor. Furthermore, such items as are not ready for TAB services shall be completed, placed in operational readiness, and TAB services shall again be requested. Complete, operational readiness, prior to commencement of TAB services, shall include the work described in the paragraph "Responsibility of Contractor."
- C. Refer to General Provisions. The Contractor shall provide the TAB Firm an area of ample size, conveniently located for storage of tools, equipment, and other items as required.

- D. The TAB Firm shall perform the services in accordance with the Associated Air Balance Council's (AABC) standards and procedures including revisions to the date of the contract.
 - 1. Perform variable volume system verification to assure the tem and its components track with changes from full flow to minimum flow.
 - 2. A systematic listing of the above testing and verification shall be included in the final TAB report.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 01 Section, Project Record Documents.
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and

that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine equipment for installation and for properly operating safety interlocks and controls.
- O. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 6. Sensors are located to sense only the intended conditions.
 - 7. Sequence of operation for control modes is according to the Contract Documents.
 - 8. Controller set points are set at indicated values.
 - 9. Interlocked systems are operating.
 - 10. Changeover from heating to cooling mode occurs according to indicated values.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.

6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" and this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. For variable-air-volume systems, develop a plan to simulate diversity.
- C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- D. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling unit components.
- K. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record the final fan performance data.
- B. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance systems similar to constant-volume air systems.
 2. Set terminal units and supply fan at full-airflow condition.
 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems:
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

- B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 - 1. Open all manual valves for maximum flow.
 - 2. Check flow-control valves for specified sequence of operation and set at indicated flow.
 - 3. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 - 4. Set system controls so automatic valves are wide open to heat exchangers.
 - 5. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Set calibrated balancing valves, if installed, at calculated presettings.
- B. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 - 1. System components that have CV rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- C. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- D. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 - 1. Determine the balancing station with the highest percentage over indicated flow.
 - 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 - 3. Record settings and mark balancing devices.
- E. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.9 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer, model, and serial numbers.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove

proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.

3.11 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

3.12 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.13 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.

2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.14 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 1. Fan curves.
 2. Manufacturers' test data.
 3. Field test reports prepared by system and equipment installers.
 4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 1. Title page.
 2. Name and address of TAB firm.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB firm who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 1. Quantities of outside, supply, return, and exhaust airflows.

2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

3.15 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 07 00

INSULATION - GENERAL

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section specifies the general requirements for furnishing and installing insulation. These requirements apply to all other Mechanical Division sections specifying insulation.
- B. All the ductwork and piping in pump rooms, mechanical rooms and equipment rooms including areas without ceilings is to be considered as exposed piping or ductwork. This also includes penthouses.

1.2 RELATED WORK

- A. Internal insulation for air units is specified in the sections on air handling units. The units do not require external insulation.
- B. Insulation. Refer to specific sections on individual insulation types.
- C. Section 09900 or 09901, Painting.

1.3 FIRE HAZARD RATING

- A. All equipment, duct and piping insulation used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements.

1.4 QUALITY ASSURANCE:

- A. Applicator shall be a company specializing in insulation application with minimum 5 years' experience.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Owner. Use materials indicated for the completed Work. Mockups shall include piping insulation, ductwork insulation and equipment insulation.

1.5 SUBMITTALS

- A. Product Data. Submit product data on each insulation type, adhesive and finish to be used in the work. Include manufacturer's installation instructions, list of materials and thickness for equipment scheduled.
- B. Samples. Make an application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with the work.

- C. Shop Drawings: Show details for the following:
 - 1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Attachment and covering of heat tracing inside insulation.
 - 3. Insulation application at pipe expansion joints for each type of insulation.
 - 4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Application of field-applied jackets.
 - 7. Application at linkages of control devices.
 - 8. Field application for each equipment type.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are listed under individual specification sections.

2.2 INSULATION

- A. Insulate in accordance with appropriate specification section.

PART 3 - EXECUTION

3.1 COMMON INSULATION REQUIREMENTS

- A. All materials shall be delivered to the site shall be dry, undamaged and maintained in good condition throughout the progress of the project.
- B. Insulation shall not be installed until all testing and inspection of pipe, duct, vessel, etc. has been completed and approved by Engineer/Owner's representative.
- C. Insulate valves, fittings, flanges and special items in accordance with appropriate specification section.
- D. Replace insulation damaged by either moisture or other means. Insulation which has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also replace any damage caused by the condensation.
- E. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- F. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- G. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

- H. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- I. Install multiple layers of insulation with longitudinal and end seams staggered.
- J. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- K. Keep insulation materials dry during application and finishing.
- L. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- M. Install insulation with least number of joints practical.
- N. Where vapor barrier is indicated, seal joints, duct wrap seams, vapor retarder (ASJ) film seams and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier coating/mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier coating/mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- O. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

3.2 ACCESSORIES

- A. Installation of accessories such as jacketing, bands, adhesives, insulation shields, coatings, finishes, etc. is specified under individual specification sections.

END OF SECTION

SECTION 23 07 13

EXTERNAL DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section provides for furnishing and the installation of external insulation on concealed and exposed ductwork, including single wall supply ductwork, outside air ductwork, and relief and return air duct work in non air conditioned spaces and other miscellaneous ductwork. It also includes insulating the tops of all supply diffusers.
- B. All the ductwork exposed to view in public spaces, in mechanical and pump rooms, crawl space and equipment rooms including all areas without ceilings is to be considered as exposed ductwork.
- C. Consider space above ceilings air conditioned if floor above is air-conditioned or if the space is a return air plenum. Consider exterior vertical chases and vertical chases leading to spaces not air-conditioned as un-air conditioned spaces.
- D. No lined ductwork is allowed on the project unless specifically noted on drawings or in the specifications.

1.2 RELATED WORK

- A. Section 23 07 00, Insulation - General.
- B. Section 23 31 13, Ductwork.

1.3 REFERENCES STANDARDS

- A. ASTM C 411 - Temperature Range.
- B. ASTM C 553 - Mineral Fiber Blanket and Felt Insulation.
- C. ASTM C 612 - Mineral Fiber Block and Board Thermal Insulation.
- D. ASTM C 1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts
- E. ASTM E 96 Procedure A - Jacket Vapor Transmission.
- F. ASTM E 119 – Standard Method of Fire Test of Building Construction and Materials.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Fiberglass:
 - 1. CertainTeed.
 - 2. JohnsManville.
 - 3. Owens-Corning.

4. Knauf Insulation.

2.2 INSULATION

- A. Type D1, Flexible Glass Fiber Insulation: Provide flexible glass fiber insulation with factory-applied, reinforced foil scrim kraft (FSK) facing vapor barrier, 1.0- pound per cubic foot density. A "K" factor of 0.27 at 75°F mean is required. Shall comply with ASTM C553 and C1290.
- B. Type D2, Semi-Rigid Glass Fiber Insulation: Provide semi-rigid glass fiber insulation adhered to UL labeled, reinforced foil scrim kraft (FSK) facing vapor barrier on the outside surface, 2.5 pound per cubic foot density. A K factor of 0.24 at 75°F mean is required.
- C. Type D3, Rigid Glass Fiber Insulation: Provide rigid board glass fiber duct insulation with integral, UL labeled, reinforced foil scrim kraft (FSK) facing vapor barrier on the outside surface, minimum density of 3 pounds per cubic foot. A "K" factor of 0.23 at 75°F mean is required.
- D. Type D4, Fire-Rated Insulation: Provide 1-1/2 inch thick, 6-pound density, ceramic fiber blanket, aluminum foil laminated on both sides, suitable for continuous temperatures of 1900°F. Insulation shall provide 2-hour fire rating and be suitable for zero clearances to combustibles at any location. Include installation and hanger support requirements in submittal.

2.3 COATINGS AND ADHESIVES

- A. Glass Fiber Insulation
 - 1. Coating. Foster 30-80 or Childers CP-38 vapor barrier coating. Permeance shall be 0.013 perms or less as tested by ASTM E96/ASTM F1249. Coating must comply with MIL-C-19565C, Type II and be QPL listed.
 - 2. Adhesive. Fosters 85-60 or Childers CP-127 adhesive. Product must comply with ASTM C916 and ASTM E84 25/50 requirements.
- B. Reinforcing Mesh. Fiberglass or polyester, 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10.

PART 3 - EXECUTION

3.1 GENERAL

- A. Do not apply insulation until ductwork has been tested.
- B. Verify surfaces are clean, foreign material removed, and dry.
- C. Where trapeze hangers are used, provide strip of non-compressible insulation between ductwork and hanger.

3.2 FIRE SAFETY REQUIREMENTS

- A. Do not extend duct coverings through walls or floors required to be fire stopped or required to have fire resistance rating. Interrupt duct coverings in the immediate vicinity of heat sources such as electric resistance or fuel-burning heaters.

3.3 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air ductwork.
 - 2. Indoor, exposed supply and outdoor air ductwork.
 - 3. Indoor, concealed or exposed return ductwork located in nonconditioned spaces.
 - 4. Indoor, concealed & exposed return air ductwork, from connection of outside air ductwork to air handling unit.
- B. Air Devices:
 - 1. Supply Diffuser.
 - 2. Uninsulated Plenums on Slot Diffusers and Linear Bar Grilles.
- C. Items Not Insulated:
 - 1. Indoor, concealed return air ductwork (in chases, above ceilings, except as noted above).
 - 2. Indoor, exposed return air ductwork (in chases, mechanical rooms except as noted above).
 - 3. Flexible connectors.
 - 4. Double wall ductwork.
- D. Definitions
 - 1. Oval ductwork shall be insulated the same as round ductwork.
 - 2. Outside air duct shall be considered ductwork (or plenum) from louver or intake hood to air handling unit.
 - 3. Pretreated outside air shall be insulated the same as supply ductwork.

3.4 DUCTWORK INSULATION APPLICATION AND THICKNESS SCHEDULE

- A. Provide insulation with minimum thickness and installed "R" valves in accordance with ASHRAE Standard 90.1-2010 Tables 6.8 2A & B, but not less than thickness specified in this specification and as required to prevent condensation:

Ductwork System	Application	Insulation Type	Insulation Thickness
Supply & Outside Air – Rectangular/Round (Hot, Cold, Combination)	Concealed Ductwork	D1	2"
Supply & Outside Air – Rectangular (Hot, Cold, Combination)	Exposed Ductwork	D3	2"
Supply & Outside Air – Round (Hot, Cold, Combination)	Exposed Ductwork	D2	2"
Air Devices	All Air Devices	D1	1"
Return Air, Relief Air, and Exhaust Air – Rectangular/Round	Concealed Ductwork	D1	1"
Return Air, Relief Air, and Exhaust Air – Rectangular	Exposed Ductwork	D3	1"
Return Air, Relief Air, and Exhaust Air - Round	Exposed Ductwork	D2	1"

3.5 TYPE D1, FLEXIBLE GLASS FIBER INSULATION

- A. Insulation shall be wrapped, in accordance with manufacturer's recommendations, on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 2 inches.
- B. Adhere insulation to ductwork with 4 inch wide strips of adhesive at 8 inches on center. In addition, secure insulation to the bottom of rectangular ductwork over 24 inches wide by the use of mechanical fasteners at no more than 18 inches on center. Weld stick clips to duct work to secure insulation. Adhesive applied stick pins are not acceptable.
- C. On circumferential joints, the 2 inch flange on the facing shall be stapled with outward clinching steel staples on 2 inch centers, and taped with a minimum 3-inch-wide strip of reinforcing mesh and vapor barrier coating. Cover all seams, joints, pin penetrations and other breaks with two coats of vapor barrier coating reinforced with reinforcing mesh. Coating shall completely cover and conceal mesh.

3.6 TYPE D2, SEMI-RIGID GLASS FIBER INSULATION

- A. All exposed ductwork in public areas and mechanical rooms shall be wrapped in accordance with manufacturer's recommendations. Firmly butt all joints together and seal longitudinal laps of factory-applied vapor barrier jacket with adhesive. Cover butt joints with a 4 inch wide strip of factory-supplied vapor barrier jacket facing adhered with adhesive. Cover all seams, joints, pin penetrations and other breaks with two coats of vapor barrier coating and reinforcing mesh.

3.7 TYPE D3, RIGID GLASS FIBER INSULATION

- A. Exposed ductwork shall be covered with rigid board insulation in accordance with manufacturer's recommendations.
- B. Fill and point up all joints, perforations and exposed edges with two coats of vapor barrier coating reinforced with reinforcing mesh. Coating shall completely cover and conceal mesh.
- C. Securely fasten insulation to metal surface with adhesive and mechanical fasteners on 12 inch centers.
- D. Sheet metal screws and discs or other approved fasteners may be used. In addition, secure insulation to the bottom of rectangular ductwork over 24 inches wide by the use of mechanical fasteners at no more than 18 inches on center. Weld stick clips to duct work to secure insulation. Adhesive applied stick pins are not acceptable.

3.8 STANDING SEAMS

- A. Insulate standing seams and stiffeners which protrude through insulation with 3-pound density, 1-1/2 inch thick, faced duct insulation, flexible blanket or rigid insulation to match duct insulation. As a vapor seal on exposed edges, use glass cloth with vapor barrier coating. Insulation should not prevent adjustment of damper operators.

3.9 AIR DEVICES

- A. Insulate backside of diffusers and uninsulated plenums on slot diffusers as indicated in application schedule.

- B. All edges of insulation should be taped to diffuser backpan with pressure-sensitive aluminum foil tapes listed and labeled under UL 181A, Part I.

3.10 TRANSFER DUCTS

- A. Line return air transfer ducts with 1/2 inch dual density type acoustical insulation. Coat exposed edges of insulation with sealant.

END OF SECTION

SECTION 23 07 19

PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Piping insulation for Chilled Piping within building envelope, other than Crawl Spaces and wet areas.
 - 2. Primary and Secondary chilled water piping shall be considered chilled water piping in these specifications.
 - 3. Furnishing and installation of insulation.
 - 4. Jackets and accessories.

1.2 REFERENCES

- A. ANSI/ASTM C 195 - Mineral Fiber Thermal Insulation Cement.
- B. ANSI/ASTM- C 547 - Mineral Fiber Preformed Pipe Insulation.
- C. ANSI/ASTM C 552 - Cellular Glass Block and Pipe Thermal Insulation.
- D. ASTM B 209 - Aluminum and Aluminum-alloy Sheet and Plate.
- E. ASTM C 449 - Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

1.3 QUALITY ASSURANCE

- A. Applicator. Company specializing in piping insulation application with five years minimum experience.
- B. Materials. UL/ULC Classified per UL 723 or Flame spread/fuel contributed smoke developed rating of 25/50 in accordance with ASTM E84.

1.4 SUBMITTALS

- A. Refer to Specification 23 07 00.
- B. Submit product data on insulating materials, including manufacturer's safety and installation instructions.
- C. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Fiberglass
 - a. Owens-Corning.

- b. JohnsManville.
- c. Knauff Insulation
- 2. Flexible Elastomeric
 - a. Armacell; AP Armaflex.
 - b. RBX Corporation.
- 3. Phenolic Foam
 - a. Dyplast
 - b. Resolco Insulphen
 - c. ITW

2.2 INSULATION

- A. Type P1: Furnish fiberglass insulation with factory applied, all service reinforced vapor barrier (ASJ) jacket having integral laminated aluminum vapor barrier and self sealing labs. Jacketing shall have a maximum water vapor permeance of 0.02 perms. Insulation shall be in accordance with ANSI/ASTM C 547 with a "K" factor of 0.23 BTU-in/hr-ft²-°F at 75°F. Insulation shall be certified by Greenguard Gold.
- B. Type P2. Furnish closed-cell expanded rubber materials complying with ASTM C534, Type 1 for tubular materials. Insulation shall have a maximum "K" factor of 0.27 Btu-in./h-ft²- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
- C. Type P5. Furnish minimum 2.5-pound density rigid closed-cell phenolic foam insulation with factory applied all service reinforced vapor barrier (ASJ) jacket having integral laminated aluminum vapor barrier. Insulation shall be in accordance with ASTM C-1126 with a maximum "K" factor of 0.15 BTU-in/hr-ft²-°F at 75°F.

2.3 INSULATION SHIELDS AND SADDLES

- A. Field Fabricated:
 - 1. Use high compression strength Phenolic Foamglas blocks (HLB 1600) that will support the bearing area at hangers and supports.
 - 2. Further support insulation at hangers and supports with a shield of galvanized metal extending not less than 2 inches on either side of the support bearing area, covering at least half of the pipe circumference, and conforming to the schedule below.
 - 3. When pipe is guided at top and bottom, metal shields should cover the whole pipe circumference.
 - 4. Adhere metal shield to insulation so that metal will not slide with respect to insulation. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).

Pipe Diameter	Insulated Section Length in Inches	Minimum U.S. Standard Gauge of Metal Shield
2 1/2" and smaller	14	16
3" to 4"	14	16
6" to 12"	24	14
14" and larger	24	12

- 5. At Contractor's option, factory-made insulation shields may be provided as made by Anvil Fig 168, equivalent by Pipe Shields, Inc., or equal. Insulation should ex-

tend at least 1 inch beyond metal. Select proper shield for service and pipe span.

6. For Type P2 insulation, factory-made insulation shields such as Armafix IPH may be used at Contractor's option.
 7. For Type P5 insulation, use minimum 5 pound density insulation or denser as required by manufacturer at all pipe supports.
- B. Saddles: Fit piping 2 inches through 10 inches operating at high temperatures with Anvil Figure 161 through 164 protection saddles, or similar saddles of proper design for specified insulation thickness. Fit pipe sizes over 10 inches with Anvil Figure 163A through 165A or similar saddle as required by insulation thickness specified.
- C. All shields are to be secured by 2 stainless steel bands, 1/2 inch wide by 0.015 inch thick with matching seals

2.4 JACKETS

- A. PVC Jackets: Provide molded or mitered covers for flanges, valves and fittings similar to Schuller Zeston 2000.
- B. Canvas or Glass Jackets and Lagging Adhesive/Coating: UL listed treated cotton fabric, 6 ounce/square yard or low odor glass cloth, Foster 30-36 AF; Childers CP-137 AF, or approved equal. Coatings shall meet ASTM D 5590 with 0 growth rating.

2.5 SEALANT, ADHESIVE AND FINISH

- A. Fiberglass - Low Temperature (Below 70°F):
1. Flashing Sealant: Furnish Childers CP 76 or Foster 95-44 elastomeric sealant at valve covers, anchors and hangers.
 2. Lap Adhesive: Furnish Childers CP-82 or Foster 85-20 to seal longitudinal laps of the vapor barrier jacket and to adhere butt joint covers.
 3. Vapor Barrier Coating: Furnish Foster 30-80 AF with reinforcing mesh on all insulated fittings, flanges, and valves. Coating shall meet ASTM D5590 with 0 growth rating. Maximum permeance shall be no greater than 0.08 perms at 37 mils dry as tested at 100°F and 90% RH per ASTM F1249. All ASJ seams shall be coated with vapor barrier coating to prevent moisture ingress. Outdoors: Foster 30-90; Childers CP-35 only. White
- B. Flexible Elastomeric
1. Adhesive: Furnish Armaflex 520 BLV Low VOC Adhesive, Foster 85-75, or Childers CP-82 to seal longitudinal laps and to adhere butt joint covers.
 2. Finish: Furnish Armaflex WB or Foster 30-64 water based latex enamel finish.
- C. Reinforcing Mesh: Fiberglass or polyester. 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10

2.6 FITTINGS

- A. Provide pre-molded fittings and elbows molded in two matching half sections of same insulation thickness as adjoining piping. As an alternative, provide mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs. No insert or blanket insulation allowed.

2.7 PRIMER

- A. Polyguard RG-CHW for surface temperatures less than 130F, RG-2400 LT for piping with surface temperatures between 130F and 250F. Application thickness shall be 25 mils.
- B. Global Encasement Rust Inhibition Primer. Application thickness shall be minimum 3 mils (dry)
- C. Sherwin Williams Pro-Cryl Universal Acrylic Primer. Application thickness shall be minimum 3 mils (dry).

2.8 ALUMINUM JACKET

- A. Piping. Furnish for finishing interior insulated pipe, a prefabricated jacket of ASTM B209 aluminum, 0.020 inch thick, with factory-applied 2-mil moisture barrier.
- B. Valves, Fittings and Flanges. Provide complete coverage of all valves, fittings and flanges, provide aluminum covers, 0.020 inch thick, ASTM B209 aluminum.
- C. Straps and Seals. Furnish 1 inch x 0.010 inch, ASTM B209 aluminum strapping and seals for applying aluminum jacket and covers to provide completely weather tight covering of all insulation including caps, flanges and end of lines.
- D. Metal Jacketing Sealant: Furnish 1/8" bead of Foster 95-44 or Childers CP-76 underneath all metal jacketing laps to prevent water entry on outdoor applications.

PART 3 - EXECUTION

3.1 PIPE

- A. Pressure testing of piping systems shall be complete prior to application of insulation.
- B. Prior to insulating piping,
 - 1. Remove all oil, grease, cutting oils, dirt and other contaminants. Use suitable solvents, steam cleaning with detergent, or fresh water wash with detergent. Follow with thorough fresh water rinse.
 - 2. Provide primer coat on all chilled and steel piping in accordance with manufacturer's recommendations, to include field welds and over factory applied paint/coating, in total compliance with mechanical identification section and compatible with and approved by the insulation manufacturer. Painting must be completed and approved prior to installation of insulation.
- C. Butt insulation joints firmly together. Seal longitudinal laps and butt strips with sealant.
- D. Type P1 Fiberglass - Low Temperature:
 - 1. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating vapor seal shall be formed between the vapor barrier jacket and the bare pipe by liberal application of the vapor barrier sealant to the exposed joint faces carried continuously down to and along 4 inches of pipe and up to an along 2 inches of the jacket.
- E. Type P2.
 - 1. Provide finish as specified on all insulation.

3.2 VALVES, FLANGES AND FITTINGS

- A. Low Temperature:
 - 1. Insulate all valves, flanges and fittings with molded fitting covers secured with wire. Thickness of insulation shall be equal to that adjoining piping.
 - 2. Finish with two coats vapor barrier coating reinforced with reinforcing mesh. The application shall provide a minimum dry film thickness of 37 mils.

3.3 CONTROL VALVE COVERS - LOW TEMPERATURE SERVICE ONLY

- A. Fabricate special covers, complete with troweled-on vapor seal, shaped to accommodate the valve stem. Insulation thickness shall be same thickness as adjoining pipe.
- B. Seal covers to valve insulation proper with adhesive so that the seal may be broken with a knife blade without damage to either part. Arrange so that cover can be removed and replaced as necessary for operation of the valve. Finish valve cover with two coats of vapor barrier coating and reinforcing mesh.

3.4 SHIELDS AND HANGERS

- A. When the insulation is jacketed in aluminum, install a length of 40-pound roofing felt 1/2 inch longer than the insulation shield between shield and jacket.
- B. Where piping hangers or anchors must be in direct contact with pipe, seal off the pipe insulation on both sides of the hanger by carrying the vapor seal down to the bare pipe. Apply insulation around the hanger ring or anchor and pipe and carry vapor barrier upward and outward along the hanger rod or anchor members to a point not less than 12 inches from the adjacent pipe. Draw wire loops tight over the vapor barrier jacket, with ends of wire bent down. Take care to avoid puncturing the vapor seal. Finish insulation as specified for flanges, and seal over adjacent vapor barrier jacket.

3.5 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions.
- B. Continue insulation with vapor barrier through penetrations.
- C. In exposed piping areas, locate insulation and cover seams in least visible locations. For outdoor installations seal jacket lap with 1/8" bead of metal jacketing sealant underneath each lap to prevent infiltration of water beneath jacket. On horizontal piping place over lap at side of pipe arranged so that water will run off of jacket and not into seam lap.
- D. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
- E. Neatly finish insulation at supports, protrusions, and interruptions. Use 1-1/2 inch Type P2 insulation to insulate drains gauges, thermometers, and strainers.

3.6 PIPING INSULATION APPLICATION AND THICKNESS SCHEDULE

- A. Provide insulation with minimum thickness and conductivity values in compliance with ASHRAE standard 90.1-2010, Table 6.8.3A&B, but not less than thicknesses specified in this specification and as required to prevent condensation. Where multiple materials are listed for a single service and location, it is the Contractor's option to choose from the allowable insulations.

Service	Location	Insulation Type	Pipe Sizes	Insulation Thickness-Inches
Chilled Water	Interior	P1	1-1/2" and smaller	1-1/2
Chilled Water	Interior	P1	2" to 6"	2
Chilled Water	Interior	P1	8" and larger	2-1/2
AHU/FCU Condensate Drains	Interior	P2	All sizes	1
Supports, protrusions, drains, gauges, thermometers and strainers	Interior/ Exterior	P2	All Sizes	1-1/2

3.7 ALUMINUM JACKET

- A. Apply aluminum jacket and covers according to manufacturer's recommendations, using aluminum strapping and metal jacketing sealant to provide completely weathertight covering. Completely encapsulate insulation on all piping, valves, flanges, reducers, etc.
- B. Provide aluminum jacket for all piping within 84 inches of finished floor in air handler mechanical rooms, pump rooms and penthouses. Do not install jacketing on AHU Condensate drains unless noted otherwise. Do not install jacketing on flexible pump connectors or expansion joints.

END OF SECTION

SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes commissioning process requirements for HVAC systems, assemblies, and equipment.

1.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend commissioning coordination meetings.
- C. Attend construction phase controls coordination meeting.
- D. Attend testing, adjusting, and balancing review and coordination meeting.
- E. Participate in HVAC systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- F. Provide information requested by the CxA for final commissioning documentation.
- G. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.3 CXA'S RESPONSIBILITIES

- A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- B. Direct commissioning testing.
- C. Verify testing, adjusting, and balancing of Work are complete.
- D. Provide test data, inspection reports, and certificates in Systems Manual.

1.4 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
 - 2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC systems, assemblies, equipment, and components to be verified and tested.

4. Certificate of readiness, signed by the Contractor, certifying that HVAC&R systems, assemblies, equipment, components, and associated controls are ready for testing.
5. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
6. Certificate of readiness certifying that HVAC systems, subsystems, equipment, and associated controls are ready for testing.
7. Test and inspection reports and certificates.
8. Corrective action documents.
9. Verification of testing, adjusting, and balancing reports.

1.5 SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

- B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC testing shall include entire HVAC installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the HVAC Contractor, testing and balancing Contractor, and HVAC Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.4 HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Sections. Provide submittals, test data, inspector record, and certification to the CxA.
- B. HVAC Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Sections 23 09 00, Instrumentation and Control for HVAC, and Section 23 09 93, Sequence of Operations for HVAC Controls. Assist the CxA with preparation of testing plans.
- C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- F. HVAC Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

END OF SECTION

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Refer to the Construction Documents for Sequences of Operations for HVAC Controls, for requirements that relate to this Section.
- C. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 01 91 13, General Commissioning, for detailed commissioning requirements.

1.2 WORK INCLUDED

- A. Provide a temperature control/energy management system and control function for the entire building. The system shall include a Direct Digital Control (DDC) System that shall communicate & be integrated to the Johnson Controls existing front end.
- B. The BAS system must be compatible with the existing Johnson Controls. Systems or building components to be monitored and/or controlled by the central campus systems include, but are not limited to, the following: temperature control, fire alarm, outside building lighting, and the start and stop of major equipment. Provide metering of primary building utilities which include electrical, chilled water, heating hot water, domestic cold water, domestic hot water, steam, irrigation water utilizing a WAGES and electrical metering system / Square D ION metering software with indication and totalization capabilities
- C. Provide Network Automation Engine (NAE) and all required wiring to integrate into existing building automation system. NAE shall include an N2 Bus and LonWorks compatibility similar to JCI NAE5520. Refer to drawings for location of new NAE.
- D. The bidding and Contract Requirements and General Requirements apply to this work.
- E. Furnish and install all components but not limited to all temperature, pressure, and flow sensors, transmitters, relays, switches, wire, and all DDC panels. Also furnish all controls, operators, power supplies, control valves, air and water flow measuring stations, transducers and wiring to connect components. Submit for approval, appropriate product data cut-sheets for all material/components intended for use prior to beginning work. Where BAS is used in specifications and drawings, it is understood to be same as DDC.
- F. The Contractor shall provide Direct Digital Control (DDC) panels complete with all microprocessors, software, terminal strips, transducers, relays, and regulated power

supply with battery backup at the mechanical room field equipment controllers and supervisory engines.

- G. The Contractor shall furnish a HVAC Terminal Equipment Controller (TEC), electronic damper actuator(s), and electronic HW valve and actuator for installation on each VAV terminal unit and fan coil unit, as applicable, by the terminal equipment manufacturer. These DDC devices shall be delivered to the manufacturer's factory in sufficient time for the terminal equipment manufacturer to meet their scheduled delivery obligations.
- H. The terminal equipment manufacturer shall provide for each VAV box an inlet flow sensor suitable for interfacing with a pressure transducer, and for VAV boxes and all other terminal equipment (fan coil units, etc.) a 24 vac, 40 va transformer, any necessary pilot control relays, and factory mount and connect these devices and the DDC controller as required for proper operation as required under this Section. The cost of factory mounting shall be included in the cost of the terminal equipment.
- I. The BAS Contractor shall provide for each TEC, a 24 vac, 40 va power source, and mount and connect these devices and the DDC controller as required for proper operation as required under this Section. All other wiring and terminations related to the TEC shall be provided by the BAS contractor.
- J. Room temperature, CO₂ sensors and humidity sensors and mounting plates shall be provided and installed by the BAS Contractor. .
- K. Temperature controls and non-DDC accessories that are standard catalog products as manufactured by Johnson Controls, Inc., will be acceptable. Industrial instrumentation supplied shall be standard catalog products of Rosemount, Honeywell, Bristol, Foxboro, Leeds and Northrup, Taylor or Brown. All coordination and execution of work pertaining to the installation, service, and guarantee, under this Section of the specifications, shall be the sole responsibility of the BAS Contractor.
- L. All controls to be installed, calibrated and adjusted by trained instrument technicians in the full-time employ of the BAS Subcontractor & low voltage electrical subcontractor.
- M. Submit engineering/wiring drawings and receive approval prior to beginning work. These drawings shall be submitted in a timely manner to provide sufficient time to review drawings so as not to hold up the project.
- N. The DDC field panels will be located in mechanical rooms as shown on the drawings. All sensor and start/stop wiring will be brought back to the panel responsible for controlling/monitoring the mechanical/electrical equipment for which the sensor, start/stop wiring is directly related. The location of these panels may not be shown on the drawings. The DDC panels in the mechanical room shall be provided with a UPS to allow operation of the panels during switchover to emergency power. The UPS shall provide a minimum of 500 va, be similar to an Invensys Powerware 120, and be installed in a NEMA 1 hinged, lockable cabinet.
- O. Division 26 shall provide power to a duplex receptacle inside each panel. Power shall be provided from a breakered, 20 amp dedicated circuit on emergency power having an insulated ground wire from the power panel ground buss wired to the duplex receptacle.
- P. The BAS Control System will perform all Sequence of Operations as required by the Design Engineer. Furnish and install a network communications trunk (N.C.T.) between DDC panels, and a separate LAN communications network between each terminal unit controller (or group of controllers) back to the DDC panel associated with the AHU which

serves the terminal units. Trunks shall be connected to the panels with CAT-6 conductors and required components (switches). In addition, the N.C.T. trunk shall be extended from the nearest Panel to an Owner-provided, network drop(s) location

- Q. The Owner shall provide the dedicated network connection between the drop(s) location and the Campus Energy Management System.
- R. Provide graphics for all new work compatible with existing campus front end system.
- S. All exposed wiring shall be in conduit (1/2" minimum), as per Division 26 Sections. Concealed wiring shall be plenum rated. All active Ethernet switches, hubs, and routers shall be Contractor-provided and installed. The conduit/wiring system required for the Energy Management System shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted
- T. The BAS contractor will be responsible for the connection from the Energy Management System to the campus (University). The Contractor will be responsible for programming the DDC panels with operational sequences and set-points as specified.
- U. Refer to Division 23 00 05 for additional commissioning requirements.

1.3 RELATED WORK

- A. All work of this Division shall be coordinated and provided by the single Building Automation System (BAS) Contractor (Also known as DDC Contractor).
- B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 23 Sections for details.
- C. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.
- D. If the BAS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.
- E. Section 01 91 13, Commissioning

1.4 SUBMITTALS

- A. General.
 - 1. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance, prior to installation.
 - 2. All product data in the submittal shall reference the paragraph number in the specification for the corresponding equipment.
 - 3. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BAS work.
 - 4. Owner & A/E Submittal Review
 - a. Two weeks after submittal has been issued the Contractor, Owner and A/E will have a meeting to review and discuss A/E and Owner's comments. The submittal will be returned approximately one week after the controls meeting.

- B. Product Data: For each control device specified.
- C. Shop Drawings:
 - 1. Schematic flow diagrams & graphic display.
 - 2. Power, signal, and control wiring diagrams.
 - 3. Details of control panel faces.
 - 4. Damper schedule.
 - 5. Valve schedule.
 - 6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
 - 7. Control System Software: Schematic diagrams, written descriptions, and points list.
 - 8. Sequences of operation.
 - 9. Software and firmware operational documentation.
 - 10. Samples of Graphic Display screen types and associated menus.
 - 11. Field quality-control test reports.
 - 12. Operation and maintenance data.

1.5 RECORD DOCUMENTATION

- A. Operation and Maintenance Manuals:
 - 1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BAS provided:
 - a. Table of contents.
 - b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
 - c. Manufacturer's product data sheets or catalog pages for all products including software.
 - d. Archive copy of all site-specific databases and sequences.
 - e. BAS network diagrams.
 - f. Interfaces to all third-party products and work by other trades.
 - 2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.6 ENERGY MANAGEMENT SYSTEM WIRING

- A. All wiring and conduit shall be installed in accordance with related Specification Section Division 26, Electrical.
- B. The conduit/wiring system required for the BAS specification Input/Output summary:
 - 1. Digital Input (D.I.) wiring (Class 2) may be run in a common conduit with Digital Output (D.O.) wiring (Class1) where local codes permit.
 - 2. Analog Input (A.I.), Analog Output (A.O.), Digital Input (D.I.), and Network Communications Trunk (N.C.T.) wiring may be run in a common conduit.
 - 3. Digital Output (D.O.) wiring run in a common conduit with Analog Input (A.I.), Analog Output (A.O.), or Network Communications Trunk (N.C.T.) is not permitted under any circumstances.
 - 4. AC line power to DDC panel shall be #12 THHN.
 - 5. Digital Output (D.O.) wiring shall be #14 THHN.

6. Digital Input (D.I.), Analog Input 4-20 mA (A.I.), and Analog Output (A.O.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
 7. Analog Input/Thermistor/or voltage types (A.I.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
 8. Network Communications Trunk (N.C.T.) between DDC panels and TEC's shall be 2 individual minimum #24 awg TSP (twisted, shielded stranded pair) cables, not to exceed 12.5 pf capacitance per foot, wire-to-wire, and not to exceed 6 twists per foot. TEC controller LAN networks shall be 1 #24 awg TSP of the same type.
- C. Wiring between DDC Panels:
1. Furnish, install and terminate individual CAT-6 cable assemblies to interconnect each mechanical room in a star configuration. Data is passed through the switch before continuing to its destination to other main building panels and to the front end. Each cable shall originate and terminate within one designated DDC panel in each mechanical room. Additionally, furnish, install and terminate individual Cat-6 cable assemblies to connect each DDC panel within the mechanical room(s) with others in that same room, as engineered by the BAS Contractor.
 2. All cable runs between mechanical rooms and /or DDC panels shall be no longer than allowed as specified in Division 27. Where runs are required that will be longer than Division 27, furnish and install an additional enclosure near the midpoint (coordinate location wit architect), to be used as a network junction box, complete with 120VAC emergency power source. Terminate and label the cables within this junction box as directed for each DDC panel.
 3. Furnish, install and make connections of all interlock, power for sensors (if required), line and low-voltage wiring external and internal to DDC panels. All wiring shall be clearly and permanently labeled as outlined below.
- D. Field devices requiring a 4-20 mA DC input signal shall be non-ground referenced.
- E. All wiring in mechanical rooms, electrical rooms, inaccessible areas, or located in areas exposed to occupant view shall be run in conduit. Plenum rated wiring shall be acceptable for installation in concealed, accessible locations. Conduit fill limit shall not exceed 40% in any portion of the conduit system.
- F. In order to facilitate maintenance, where multiple sensors or devices are connected to a common raceway or conduit, each sensor or device shall be individually connected to a common (non-sensor or device) junction box, which shall then be attached to the common conduit. Under no circumstances shall sensor or device wiring or tubing be routed through any other sensor or device's specific enclosure or junction box.
- G. All wiring shall be labeled at both ends and at any spliced joint in between. Wire and tubing shall be tagged using a system similar to the Panduit P1 Self Laminating System that utilizes a thermal transfer (or equivalent) printer with a minimum font size of Arial 10. In addition to tagging at field device end and at spliced joints, a tag shall be placed 6 inches after entering each DDC panel. Identification and tag information shall be included in engineering/wiring submittal which must be submitted for Owner approval prior to beginning work. Tag information shall coincide with equipment/point information as written in the specification input/output summary
- 1.7 SYSTEM VERIFICATION--PROCEDURE TO BE FOLLOWED
- A. Provide minimum 2 week written notice for all inspections.

- B. Upon completion of all external sensor mounting, terminations, and wiring into and out of the DDC panels), the Owner shall inspect and approve this work. The BAS Subcontractor shall make his Representative(s) available and coordinate with the Owner during this inspection process. At the successful conclusion of this inspection, contractor shall provide a written report stating all work is complete. BAS Subcontractor, General Contractor and Owner's Rep shall sign. This should be filed with Project Commissioning/Startup documents.
- C. Upon such approval being achieved, the BAS Contractor shall make terminations within the DDC panels.
- D. Following completion of the work and the DDC panel tie-in, a performance test shall be conducted by the Owner in the presence of the BAS Contractor and his appropriate Subcontractors.
- E. The BAS Contractor shall be present for the testing of proper operation of each and every physical system point to which the Contractor has provided devices, wiring, in order to verify the equipment and installation provided by them (their portion of the work), i.e., when the Owner commands a point, the Contractor verifies in the field that the commanded point operates properly. At the successful conclusion of this inspection, contractor shall provide a written report stating all work is complete, calibrated and functioning properly per the specified sequences of operation. An electronic and paper copy of which will be provided to UES for signature by the BAS Subcontractor, General Contractor and Owner's Representative. This should be filed with Project Commissioning/Startup documents. A representative of the BAS Contractor that can revise control sequences shall be available on site as necessary to make changes during the system verification.
- F. Owner's Representative shall attend initial inspection and verification of completed punch list for items in paragraphs 1.5C and 1.5F of this Section. Further inspections required due to incomplete/incorrect work shall be at Contractor's expense.
- G. Upon conclusion of final checkout and acceptance, the Contractor's responsibility reverts to warranty of materials and installation herein specified. System shall be warranted for a period of two (2) years.
- H. The Contractor shall coordinate and include the Commissioning Agent as required for the above activities. Commissioning agent will coordinate and witness functional performance test procedures. Refer to 01 91 13 for additional details.

1.8 COORDINATION OF EFFORT

- A. It is the responsibility of the Contractor to schedule and coordinate with the installer of all furnished equipment.
- B. It is the Contractor's responsibility to schedule the accomplishment of these activities to allow for nominal system checkout, performance tests and balancing within the contract performance period.

1.9 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.10 SYSTEM GRAPHICS

- A. Provide a cover page for the project to include graphic links including, but not limited to:
1. Air Handling Equipment
 2. Chilled and Heating Water Pumps
 3. Domestic Water Pumps
 4. Fans
 5. Outside Air Handling Equipment
 6. Supply Air Floor Plan
 7. Exhaust Air Floor Plan
 8. Schedules
 9. Other items as indicated on the construction documents
- B. Floor plans shall show the following:
1. Show room numbers or list of group of rooms within the colored areas
 2. Colored areas indicate different graphic links such as 1st floor North, etc.
 3. Links to other floors along with chilled and heating water system links.
 4. Links to sequence of operations
 5. Links to any operations schedules
- C. Floor Plan of supply shall show the following:
1. Indicate room numbers on plan
 2. Indicate different AHU coverage with different colored cloud
 3. Indicate VAV box locations along with ductwork
 4. Indicate room temperatures for each zone
- D. Typical VAV box shall show the following:
1. AHU serving VAV box
 2. Supply CFM and damper position
 3. Reheat valve position
 4. Box status, heat or cool
 5. Fan proof
 6. Room temperature and set point
 7. Occupancy sensor state (if available)
- E. Exhaust fan floor plan layout shall show the following:
1. Indicate room numbers on plan
 2. Indicate with different colored bubble or cloud the boundaries of each exhaust fan.
 3. Link to each exhaust fan that is shown on that floor
- F. Schematic of outside air units shall show the following:
1. Schematic indicating what other AHU's the outside air handler serves
 2. Indicate flows to each AHU
- G. Air Handling Unit (and PTOA) shall show the following:
1. Provide feedback on devices, but not limited to items such as temperatures, fan speed, static pressure set point and actual, valve position, filter status, airflow measuring station CFM, etc.
 2. Graphics to be a true representation of the actual field equipment.
- H. Typical Variable Refrigerant Flow Systems shall show the following:
1. Compressors serving each fan coil unit
 2. Supply airflow at each fan coil unit
 3. Compressor status and %loading

4. Fan coil status
 5. Fan coil room temperature and humidity
- I. Other
1. Refer to construction documents for other systems that require graphics.
 2. Graphics shall include feedback on all devices including set point and actual values.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. The Building Automation System (BAS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other Owner provided networks.
- B. The Building Automation System shall consist of the following:
1. Standalone Network Automation Engine(s).
 2. Field Equipment Controller(s).
 3. Input/Output Module(s).
 4. Local Display Device(s).
 5. Portable Operator's Terminal(s).
 6. Distributed User Interface(s).
 7. Network processing, data storage and communications equipment.
 8. Other components required for a complete and working BAS.
- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices. In existing installation, re-use existing controls equipment (Small Animal Hospital).
- D. System architectural design shall eliminate dependence upon any single device for control execution:
1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
 2. The System shall maintain all settings and overrides through a system reboot.
- E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
- F. Acceptable Manufacturers:
1. Johnson Controls, Metasys
- G. Integration with Existing Johnson Controls BAS:
1. The BAS Contractor for this new project shall provide the following:
 - a. The BAS contractor shall provide any and all necessary connectivity licenses within the cost of the bid. Licenses shall allow specified BAS point information to be broadcast out of the BAS expansion to the existing Johnson Controls BAS.

2.2 ACCEPTABLE CONTRACTORS

- A. Mechanical contractor shall not serve as BAS contractor. Acceptable BAS contractors, provided they comply with these specifications, are:
1. Johnson Controls, Inc. (branch office)
 2. No exceptions

2.3 FIELD DEVICES

- A. Temperature Sensors: Platinum Resistance Temperature Detector, 0°F to 400°F range, 100 ohms at 0°C, 316 stainless steel sheath, single element, ¼ inch diameter sheath. For water sensing provide 316 stainless steel thermowells. Use 304 stainless steel extension fitting to extend assemblies through insulating materials. Provide spring-loaded sensors to ensure good surface contact in thermowells. Provide matched sensor/transmitter assemblies, NIST certified to be accurate to within ± 0.1 degrees F from 20 degrees F to 70 degrees F for chilled water monitoring, accuracy of $+ / - 0.5$ degrees F from 30 degrees F to 250 degrees F for condenser water, hot water, or domestic water monitoring, and accuracy of $+ / - 0.5$ degrees F from 20 degrees F to 120 degrees F for all other temperature monitoring. Install on chilled water lines such that condensation does not collect in connection head. Duct temperature sensors shall be averaging type. Water sensors shall be provided with a separable stainless steel well. Outside air wall mounted sensors shall be provided with a sun shield. Accuracy of transmitter shall be unaffected by wiring distances up to 700 feet. Johnson Controls, Minco, or Hy-Cal only. Immersion sensors for piping shall be Dwyer Series TTE explosion-proof RTD temperature transmitter with fully configurable ranges and display options or equal by Rosemount.
- B. Room Sensors:
1. Each room temperature sensor shall come complete with a terminal jack and override switch integral to the sensor assembly. The terminal jack shall be used to connect the portable operator's terminal to control and monitor all hardware and software point associated with the terminal unit.
 2. The Humidity Sensor shall provide a 0 to 100% range corresponding to an isolated 4 to 20 Ma output. Accuracy of $\pm 2\%$ RH, with maximum drift of 1% per year.
 3. An override switch will initiate override of the night setback or unoccupied mode to normal (day) operation when activated by the occupant. The switch function may be locked out, canceled or limited as to time or temperature in software by an authorized operator or a central or remote operator's terminal.
 4. Space temperature sensors may be Thermistor or 4-20 mA output RTD. The room sensor shall be firmly attached to the wall using approved construction techniques. Double-sided adhesive tape in lieu of screws is not acceptable.
 5. The room sensor shall be accurate to within $\pm 0.5^\circ\text{F}$ and have a setpoint adjustment range of 45°F to 85°F.
 6. Room carbon dioxide shall provide a range from 0 to 2,000 ppm CO₂, and be accurate to within ± 100 ppm. The CO₂ sensor shall experience less than 1% drift per year for the first two years of operation and negligible drift thereafter, no calibration of the CO₂ sensor is necessary.
 7. Room sensors shall be full featured cover in all areas.
- C. Temperature Transmitters: Temperature transmitters shall be designed for 4-20 mA DC output for Platinum RTD millivolt input sensor (as specified above). Accuracy shall be the same as specified for the temperature sensors. Stability shall be $\pm 0.2\%$ of calibrated span for 6 months. Transmitter shall be a part of the temperature sensor assembly and shall be in a moisture-proof housing with a moisture-proof seal between the sensor and

transmitter. Immersion sensors for piping shall be Dwyer Series TTE explosion-proof RTD temperature transmitter with fully configurable ranges and display options or equal by Rosemount.

- D. Humidity Transmitter Space: Sensor shall provide a 0 to 100 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Accuracy of + / - 2 percent RH, with maximum drift of 1 percent per year. Sensor shall be equipped with LCD display. Johnson Controls model number HC-7603.
- E. CO₂ Duct-Stat Indoor AQ Sensor: CO₂ sensor shall be Johnson Controls model number CD-P00-00. The unit shall be self-contained for wall mounting application. The unit shall have a fast response and shall have 0-1 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Visual alarm is not to be provided. The monitor shall utilize the photo acoustic sensor with VOC sampling capability.
- F. Electric Room Thermostats: Provide line voltage room thermostats with cover. Set point must be adjustable from approximately 50 to 100 Deg. F. Minimum rating is 6 amps at 120 VAC. Provide removable setting knob. Housings shall not contain thermometers.
- G. Duct Relative Humidity Sensor: Duct relative humidity sensors used in the calculation of enthalpy shall be similar to Siemens QFM Series Duct Relative Humidity. The sensor shall have an accuracy of +/- 2% RH. Provide unit with housings suitable for return air plenum installations. Filter material shall be Teflon. The unit shall be operating range of 0 to 100% RH and have a 4 to 20 mA or 0 to 10 Vdc linear output.
- H. Flow Transmitters: Flow transmitters shall provide a 4-20 mA DC signal output proportional to flow. Accuracy of $\pm 0.25\%$ of calibrated span. Temperature Limits: -40°F to +220°F. Stability of $\pm 0.25\%$ of upper range limit for 6 months. Range of transmitter shall match flow conditions. Flow transmitter shall be Rosemont only.
- I. Pressure Transmitters: Transmitters for water pressure shall provide a 4-20 mA DC signal output directly proportional to pressure. Device shall be constructed with corrosive resistant stainless steel wetted parts and have a die-cast aluminum enclosure specifically designed for NEMA4/IP65 service. Accuracy of $\pm 0.5\%$ of calibrated span. Span not over 200% of sensed pressure. Stability $\pm 0.5\%$ of upper range limit for 6 months. Stainless steel diaphragm, viton O-rings. Temperature limits: -20°F to 220°F. Rosemount, Setra, or Bristol, only.
- J. Fan proof-of-flow switches shall be UL listed adjustable setpoint and differential pressure type. Switches shall be piped to fan inlet and outlet. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inch w.c. All pressure tubing on roof shall be stainless steel. Hawkeye or equivalent.
- K. Pump proof-of-flow switches shall be UL listed adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 150 psi body. Differential pressure switches shall have valved manifold for servicing. Hawkeye or equivalent
- L. Current Status Switch: Provide a high performance miniature split-core current status switch with adjustable set point (where indicated). The current status switch shall have an operating range of between 1.25 – 50 amps and be able to detect belt loss and mechanical failure. Shall be Veris Hawkeye H908 or equal.

- M. Air flow and static pressure analog sensors shall be $\pm 0.5\%$ accuracy, range suitable for the low velocity pressures to be encountered, be selected for approximately 50% over-range, and have an electronic 4 to 20 mA analog output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span. Rosemount, Dresser Industries/Ashcroft XLDP or Setra C-264, only.
- N. Electric Low Limit Duct Thermostat: Snap-acting, two pole, single throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint, requiring minimum 15 feet length of bulb. Provide one thermostat for every 20 sq ft of coil surface.
- O. Air Flow Control Dampers:
1. Rectangular
 - a. Frame: 5 inches x 1 inch x minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
 - b. Blades:
 - 1) Airfoil-shaped, single-piece.
 - 2) All proportional (modulating and mixing) control dampers shall be opposed blade type and all two-position dampers shall be parallel-blade types.
 - 3) Heavy duty 6063-T5 extruded aluminum.
 - 4) Maximum 6 inches (152 mm).
 - c. Bearings: Molded synthetic sleeve, turning in hole in frame.
 - d. Seals:
 - 1) Blade: Extruded type for ultra-low leakage from -0 to 200 degrees F. Mechanically attached to blade edge.
 - 2) Jamb: Flexible metal compression type.
 - e. Linkage: Concealed in frame.
 - f. Axles: Minimum 1/2 inch diameter plated steel, hex-shaped, mechanically attached to blade.
 - g. Finish:
 - 1) Mill aluminum for dampers in exhaust airstreams.
 - h. Performance Data:
 - 1) Closed Position: Maximum pressure of 13 inches w.g. at a 12 inch blade length.
 - 2) Open Position: Maximum air velocity of 6,000 feet per minute.
 - 3) Leakage: Maximum 5.2 cubic feet per minute per square foot at 4 inches w.g for size 48 x 48 inches.
 - 4) Pressure Drop: Maximum 0.03 inch w.g. at 1,500 feet per minute across 24 inch x 24 inch damper.
 - i. Similar to Ruskin CD-50
 2. Round
 - a. Frame: Minimum 12 gage x 8 inches deep galvanized steel, 18 inches diameter and above. Flange: Minimum 12 gage x 1-1/2 inches.
 - b. Blade: Single skin, minimum 16 gage or Double skin, minimum 18 gage. Provide blade stiffeners as required.
 - c. Blade Stop: Neoprene sponge.
 - d. Axle: Minimum 1/2 inch diameter continuous plated steel rod to 24 inches diameter, 3/4 inch diameter above 24 inches diameter.
 - e. Bearings: Flange stainless steel pressed into frame.
 - f. Blade Seals: Provide seals as required to meet minimum leakage indicated. Mechanically attach blade seals to blade
 - g. Finish: Mill galvanized.

- h. Maximum Static Pressure: 4.0 inches w.g.
 - i. Performance Data for Damper Diameter of 48 inches, AMCA 500:
 - 1) Maximum System Velocity: 2,500 feet per minute.
 - 2) Leakage with Sponge Seals:
 - a) Percent of Maximum Flow: 1.40.
 - b) Total Leakage: 35 cubic feet per minute.
 - j. Similar to Ruskin CDRS82
- P. Air Flow Measurement Station:
- 1. Industrial Thermal Dispersion Technology Type, Similar to Ebtron, Inc. Model GT. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter.
 - 2. Each unit shall operate on 24 VAC.
 - 3. Each sensing point shall independently determine the airflow rate and temperature, and shall equally weight and average by the transmitter prior to output. Pitot tube arrays are not acceptable.
 - 4. A single manufacturer shall provide probe and transmitter.
 - 5. The operating range shall be from 0 - 5000 fpm with accuracy of $\pm 2\%$ over the entire operating airflow range and be verified against standards that are traceable to NIST.
 - 6. The transmitter shall be capable of communicating with the host controls using 0-10VDC and 4-20ma, RS-485 and BACnet.
 - 7. Sensors shall be UL listed.
 - 8. Manufacturer shall have review and approve placement in field, and provide written report to engineer indicating airflow measuring stations are installed in accordance with manufacturer's installation requirements.

2.4 SUPERVISORY CONTROLLERS

- A. The Supervisory Controller shall be a fully user-programmable, supervisory controller. The Supervisory Controller shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Supervisory Controllers.
- B. Processor – The supervisory controllers shall be microprocessor-based with a minimum word size of 32 bits. It shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. Supervisory Controller size and capability shall be sufficient to fully meet the requirements of this Specification.
- C. Memory – Each Supervisory Controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
- D. Hardware Real Time Clock – The Supervisory Controller shall include an integrated, hardware-based, real-time clock.
- E. The Supervisory Controller shall include troubleshooting LED indicators to identify the following conditions:
 - 1. Power - On/Off
 - 2. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
 - 3. Ethernet Connection Speed – 10 Mbps/100 Mbps/1000 Mbps
 - 4. FC Bus – Normal Communications/No Field Communications
 - 5. Peer Communication – Data Traffic between Supervisory Control Devices

6. Run –Running/in Startup/Shutting Down/Software Not Running
7. Bat Fault – Battery Defective, Data Protection Battery Not Installed
8. 24 VAC – 24 VAC Present/Loss Of 24VAC
9. Fault – General Fault

- F. Communications Ports – The Supervisory Controller shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
1. Minimum (1) USB port
 2. Minimum (1) URS-232 serial data communication port
 3. Minimum (1) RS-485 port
 4. One (1) Ethernet port

2.5 APPLICATION CONTROLLERS

- A. Based on the Building Automation System selected for the project, the following products are acceptable. If the project has selected Johnson Metasys System as the BAS, then the acceptable application controllers must be the Johnson Metasys product. In all cases the acceptable application controllers must use BACnet™ as the native communication protocol between controllers, control panel, and front-end software.
- B. Acceptable Products:
1. Johnson Metasys: Field Equipment Controllers

2.6 GENERAL - APPLICATION CONTROLLERS

- A. Definition: An Application Controller, for this specification, could be an AAC (Advanced Application Controller), an ASC (Application Specific Controller), or and Terminal Equipment Controller (TEC). These would be used on Primary Equipment and Terminal Equipment, respectively.
- B. Each Application Controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output, minimum 8 bit A to D conversion, and include voltage transient and lightning protection devices. Firmware revisions to the module must be able to be made from the local workstation, portable operator terminals or from remote locations over modems or LANs.
- C. The Application Controllers for Primary Equipment shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. The controller, in conjunction with the expansion modules, shall act as one application controller.
- D. All point data, algorithms and application software within the controllers shall be custom programmable.
- E. Each Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/write-able nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation.
- F. Each Application Controller shall be configured on the workstation/server software as a BACnet™ device. All of the points shall be configured as BACnet objects. Each controller

shall include self-test diagnostics which allow the controller to automatically relay to the system supervisory engine(s) any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.

- G. Each Application Controller should be capable of scheduling, either by using an on-board real-time clock or by receiving the time from the system supervisory engine(s).
- H. Each Application Controller shall contain both software and firmware to perform full DDC PID control loops.
- I. Each Application Controller shall contain a port for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.
- J. If being installed outdoors, the Application Controllers shall be capable of being mounted directly in or on the equipment located outdoors. The Application Controllers shall be capable of proper operation in an ambient temperature environment of -20 degrees F to + 150 degrees F.
- K. Input-Output Processing:
 - 1. Digital outputs shall be relays or triacs, 24VAC or VDC minimum. Each output shall be configurable as normally open or normally closed.
 - 2. Universal inputs shall be capable of, 0-20mA, dry contact, and 0-5VDC, 2-10VDC or 0-10VDC.
 - 3. Analog output shall be electronic, voltage mode 0-10VDC, 2-10VDC or current mode 4-20mA.
 - 4. Enhanced Zone Sensor Input shall provide one thermistor input, one local set point adjustment, one timed local override switch, and an occupancy indicator.
 - 5. All programming sequences shall be stored in non-volatile memory. All programming tools shall be provided as part of the system. Provide documentation of all programming including configuration files.
- L. Each Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the Application Controller. All operating parameters for application programs residing in each Application Controller shall be stored in read/write-able nonvolatile flash memory within the controller. Firmware revisions, application programs and program modifications to the controller shall be capable of being performed over the Wide Area Network (WAN).
- M. Each Application Controller shall be able to support various types of zone temperature sensors, such as temperature sensor only, temperature sensor with built-in local override switch, with set point adjustment switch.
- N. Each Application Controller for VAV application shall have a built-in air flow transducer for accurate air flow measurement in order to provide the Pressure Independent VAV operation.
- O. Each Application Controller for VAV applications shall have an integral direct coupled electronic actuator. If the actuator is not integral to the controller, the controller/actuator assembly shall be factory tested and approved for the intended use. The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque. The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly. The actuator shall not require any limit switches, and shall be electronically protected against overload. When reaching the damper or actuator end position, the actuator shall automatically stop. The gears shall be manually disengaged with a button

on the assembly cover. The position of the actuator shall be indicated by a visual pointer. The assembly shall have an anti-rotational strap.

- P. Each Application Controller shall have LED indication for visual status of communication and power.
- Q. Astronomical Time: Astronomic capability shall allow the system to calculate sunrise and sunset times based on geographical location, and incorporate Daylight Savings Time, for dusk-to-dawn control or dusk-to-time control. This is required in any Application Controller with I/O for the Exterior lighting circuit(s). The Application Controller may receive this value from the Global Building Controller and fail to a "safe" position (ie., lights fail on) upon a loss of communication from the Global Building Controller.
- R. In the event of a loss of communication, the Application Controller shall control from a standalone algorithm which maintains the assigned space temperature until communication is restored.
- S. UPS: Uninterruptible Power Supply(s) is(are) required for any Application Controller (on primary or terminal equipment) that monitors or serves emergency and/or critical equipment, locations or points.
- T. All Application Controller level objects shall be exposed as BACnet Objects.
- U. Primary Equipment shall be controlled using one Application Controller when possible. A single controller with adequate Input/Output and resource capacity shall be used for a single piece of equipment as opposed to using two or more smaller controllers to house the programs for one piece of equipment.
- V. Each Application Controller for Primary Equipment shall contain the following as Spare I/O:
 - 1. Minimum of: (3) Spare Universal Inputs (or 2-DIs and 1-AI), (1) Spare AO, and (2) Spare DOs.
 - 2. In addition to the Minimum, the Application Controller shall have 10% Spare I/O, of each type; UI (or DI and AI), AO and DO.

2.7 CONTROL VALVES

- A. Terminal Unit Control Valves:
 - 1. Characterized Ball, Forged brass body, Stainless Steel trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
 - 2. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 - 3. Sizing: 5-psig maximum pressure drop at design flow rate, to close against pump shutoff head. Select control valves for a minimum Cv of 1.0 to reduce the risk of system dirt accumulating in very small orifices in characterizing-discs.
 - 4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
- B. Butterfly Valves:
 - 1. 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
 - 2. Body Style: Lug.
 - 3. Disc Type: Elastomer-coated ductile iron.
 - 4. Sizing: 1-psig maximum pressure drop at design flow rate.

2.8 VALVE AND DAMPER ACTUATORS

- A. Electronic direct-coupled actuation shall be provided.
- B. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable.
- C. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
- D. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are acceptable for valves larger than 4".
- E. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation.
- F. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA analog control input and provide a 2 to 10VDC or 4 to 20mA operating range.
- G. Actuators capable of accepting a pulse width modulating or three-point floating control signal are acceptable for specific uses only, but are generally not preferred. Typically, these uses would be fin tube radiation control valves or small (less than 1 gpm) re-heat control valves..
- H. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 10VA. Actuators operating on 230VAC shall not require more than 11VA.
- I. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque shall have a manual crank for this purpose.
- J. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.
- K. Actuators shall be provided with a conduit fitting.
- L. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.
- M. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of start-up, per Start-up Report or Cx documentation.

- N. Manufacturer shall be ISO9001 certified.
- O. Electronic Damper Actuators:
 - 1. Electronic damper actuators shall be equal to Johnson Controls M Series actuator.
 - 2. For air handling unit isolation dampers, the actuators shall be electric with spring return. The actuators shall be able to open and close in less than 30 seconds.

2.9 COMPRESSED AIR SYSTEM

- A. No controls air compressor is required for this project.

PART 3 - EXECUTION

3.1 GENERAL

- A. All DDC panels shall be connected to emergency power system.

3.2 LAMINATED SEQUENCE OF OPERATION

- A. For each piece of equipment, including, but not limited to pumps, air handling units, fans, fan coil units, etc., provide a laminated sequence of operation, including control schematic, to be mounted on the wall in the mechanical rooms or at location as indicated by Owner.

3.3 INPUT/OUTPUT SUMMARY

- A. The I/O Summary on the drawings is provided as a list of the minimum points required by this contract for connection to the Energy Automation system. Furnish all devices, wiring, tubing, etc., necessary to serve and transmit to the DDC panels. Any points not shown on the I/O Summary yet required to accomplish the sequence of operation shall be provided under this contract at no additional cost to the Owner.

3.4 EQUIPMENT, AIR HANDLING UNIT AND FAN START-UP AFTER POWER FAILURE

- A. In case of power failure, all AHUs and fans with 7-1/2 HP and larger motor shall be energized as follows upon restoration of normal power: Fifteen seconds (adjustable) after restoration of power, motors shall be started sequentially at 15 second intervals (adjustable) through the DDC system. Initiate start-up with:
 - 1. AHU-1
 - 2. AHU-2
 - 3. All other equipment to start sequentially after air handling units are verified on.
- B. Kitchen fan systems and make up air systems shall be restarted one hood system at a time.
- C. DDC to send alarm if any equipment does not start within 15 minutes and omit that item from remaining starting sequence.

3.5 INSTALLATION

- A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

- B. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- C. Contractor shall install labels and nameplates to identify control components according to Section 23 05 53, Identification for HVAC Piping and Equipment.
- D. Contractor shall install hydronic instrument wells, valves, and other accessories according to Section 23 21 14, Hydronic Piping.
- E. Contractor shall install duct volume-control dampers according to Division 23 Sections specifying air ducts.
- F. Install electronic and fiber-optic cables as applicable according to Division 27.

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
 - 3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - 6. Test each system for compliance with sequence of operation.
 - 7. Test software and hardware interlocks.
- C. DDC Verification:
 - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 - 4. Check instrument tubing for proper fittings, slope, material, and support.
 - 5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 - 6. Check temperature instruments and material and length of sensing elements.
 - 7. Check control valves. Verify that they are in correct direction.
 - 8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
 - 9. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section, Demonstration and Training.
- B. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans. Refer to Section 01 91 13, General Commissioning, for contractor training requirements.

3.8 FUNCTIONAL PERFORMANCE TESTING

- A. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING AND FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Chilled-water piping.
 - 2. Air-vent piping.
- B. Related Specifications
 - 1. Section 23 05 19, Meters and Gauges, for HVAC Piping for thermometers and gauges.
 - 2. Section 23 05 23, General Duty Valves for HVAC Piping, for valves
 - 3. Section 23 05 29, Hangers and Supports, for hangers and supports.
 - 4. Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.

1.2 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Pipe
 - 2. Fittings and accessories
- B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
- C. Cleaning/Flushing Plan: This must be submitted and approved prior to any piping being installed. Plan, including all steps to be taken to ensure the piping installation will be cleaned properly prior to: service, circulation through equipment, or connection to another system. This shall include, but not be limited to:
 - 1. A step by step explication of the process.
 - 2. Drawing(s) indicating flow (gpm) values required to meet the minimum velocity in each pipe.
 - 3. Drawing(s) indicating the phase(s) in which the system will be cleaned as required to ensure the minimum velocity will be maintained in each section of piping. It is expected that multiple phases will be required to achieve the minimum velocities in all of the piping safely.
 - 4. Drawing(s) indicating locations of the required temporary connections, valves, strainers, and bypasses.
 - 5. Cutsheet of the temporary pump to be used during flushing.
 - 6. Water treatment and pipe cleaning chemicals.
- D. Field quality-control test reports.
- E. Submit certification of welder's qualifications to perform the required welding operations.
- F. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- B. Provide domestic manufactured piping and fittings.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Protect piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions.
- B. Piping shall be shipped from the factory with capped ends and stored on supports off the ground with ends covered at all times to prevent nesting of insects, birds, and other animals. Any pipe found to be without end-caps or not raised off of the ground should be cleaned by the contractor prior to installation.
- C. Protect piping from accumulation of dirt and debris in and around piping/components.

1.5 OPERATION AND MAINTENANCE DATA

- A. Operation and maintenance manuals shall include the following information:
 - 1. The approved submittal with all approved items present (not a partial re-submittal)
 - 2. Chemicals used in cleaning, flushing, inhibiting, and final water treatment.
 - 3. Water quality test reports from the cleaning process.

PART 2 -PRODUCTS

2.1 STEEL PIPING AND FITTINGS

- A. 2 inches and less in diameter. ASTM A 53, Grade B, standard-weight seamless black steel pipe with standard-weight seamless steel welded fittings, satisfying ASTM A 234, Grade WPA or WPB, ANSI B16.9.
- B. 2-1/2 inches to 10 inches in diameter. ASTM A 53, Grade B, standard-weight seamless or electric-resistance welded black steel pipe with standard-weight seamless steel welded fittings, satisfying ASTM A 234, Grade WPA or WPB, ANSI B16.9.
 - 1.

2.2 COPPER PIPING AND FITTINGS

- A. ASTM B88, hard drawn Type L seamless copper tube with wrought copper fittings, ASTM B16.22.

2.3 JOINTS

- A. Screwed (Steel Piping, 2" and smaller):
 - 1. Make screwed joints using machine-cut ANSI taper pipe threads.
 - 2. Apply suitable joint compound, such as Teflon tape to the male threads only.

3. Ream pipe to full inside diameter after cutting. All-thread nipples are not permitted.
- B. Dissimilar Metals: Make joints between copper and steel pipe and equipment along with steel pipe and ductile iron pipe using insulating unions.
1. Provide insulating unions as manufactured by Crane, EPCO Sales, Inc. or approved equivalent.
- C. Solder Joints (Copper Piping):
1. Prior to making joints, cut pipe square and ream to full diameter. Clean exterior of pipe and socket. Apply thin coat of suitable fluxing compound to both pipe and socket, and fit parts together immediately.
 2. Heat assembled joint only as required to cause the solder to flow. Run the joint full, slightly beaded on the outside, and wipe to remove excess solder.
 3. Utilize lead free solder. Use silver brazing alloy or Sil-Fos on refrigerant piping and on underground piping.
- D. Welded (Steel Piping, 2-1/2" and larger):
1. Make welded joints as recommended by the standards of the American Welding Society.
 2. Ensure complete penetration of deposited metal with base metal.
 3. Provide filler metal suitable for use with base metal.
 4. Keep inside of fittings free from globules of weld metal.
 5. Do not use mitered joints.
 6. Use standard weld elbow fittings for changes of direction or cut a standard elbow for odd angles.
- E. Flanged:
1. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe and equipment. Align bolt holes to straddle the vertical, horizontal or north-south centerline. Do not exceed 3/64 inch per foot inclination of the flange face from true alignment.
 2. Use flat-face companion flanges only with flat-faced fittings, valves or equipment. Otherwise, use raised-face flanges.
 3. Install proper gaskets, suitable for intended service and factory cut to proper dimensions. Red rubber gaskets are not acceptable. Garlock gaskets or EPDM shall be used. Apply non-stick clean surface lubricant coating to both sides of gaskets.
 4. Use ANSI nuts and bolts, galvanized or black to match flange material. Use galvanized steel nuts and bolts underground, coated with tow coats of coal tar enamel. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets. Use anti-seize compound on all bolts above and below grade. Bolt threads not to protrude more than 2 threads past nut.
 5. Use carbon steel flanges conforming to ANSI B16.5 with materials conforming to ASTM A 105, Grade II or ASTM A 108, Grade II. Use welding neck type flanges at all fittings and on all pipe.
 6. Flanges for ductile iron pipe are specified in sections using that pipe.
 7. Keep flange covers on equipment and shop-fabricated piping until ready to install in system.

2.4 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8 inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Gasket Material: Thickness, material, and type suitable for fluid to be handled, and working temperatures and pressures.

2.5 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Unions(for connecting to equipment where OEM connection provided is plastic):
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Charlotte Pipe and Foundry Company.
 - b. IPEX Inc.
 - c. KBi.
 - d. NIBCO INC.
 - 2. MSS SP-107, CPVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.6 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
 - 2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180°F.

- D. Dielectric Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Calpico, Inc.
 - b. Lochinvar Corporation.
 - 2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.

2.7 UNIONS

- A. Use 150-pound standard (300-pound WOG) malleable iron, ground joint unions with bronze seat. Provide flanged union joints on piping larger than 2-1/2 inches.

2.8 BRANCH CONNECTIONS

- A. For Pipe 2 inches and smaller, use threaded fittings for steel pipe. For threaded piping, use straight size of reducing tee.
- B. For 2-1/2 Inches through 20 inches. For welded piping, when branch size is the same as and one size smaller than header size, use welding tee. Use Weldolet when branch is two or more sizes smaller than header. For threaded branch connections, use thread-o-let welded to header.

2.9 GASKETS

- A. Provide gaskets between flanges of all flanged joints. Inside diameter of gaskets shall conform to nominal pipe size. Gaskets shall be ring type between raised face flanges and full face between flat face flanges with punched bolt holes and pipe opening.
- B. Gaskets shall be cut from 1/8 inch thick non-metallic, non-asbestos gasket material suitable for operating temperatures from -150°F to +750°F. Garlock or equal. For pipe smaller than 6 inches, use 1/16 inch thick gasket.

2.10 FLOOR AND CEILING PLATES

- A. Provide chrome-plated floor and ceiling plates around pipes exposed to view and passing through walls, floors, partitions, or ceilings in finished areas. Size plates to fit pipe or insulation and securely lock in place.

PART 3 -EXECUTION

3.1 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- N. Install valves according to the appropriate section.
- O. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- P. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- Q. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- R. Identify piping as specified in the above referenced specification section.
- S. Support piping adequately to maintain line and grade, with due provision for expansion and contraction.
- T. Use only long radius elbows on steel and copper piping unless a short radius elbow is specifically shown on the drawings.
- U. Slope condensate drain piping at a minimum 1/8 inch per foot in the direction of flow.

3.2 WELDING

- A. Weld and fabricate piping in accordance with ANSI Standard B31.9, latest edition, Code for Pressure Piping. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.
- B. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.
- C. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
- D. Do not split, bend, flatten or otherwise damage piping before, during or after installation.
- E. Remove dirt, scale and other foreign matter from inside piping before tying in sections, fittings, valves or equipment.

3.3 OFFSETS AND FITTINGS

- A. Because of the small scale of drawings, the indication of all offsets and fittings is not possible. Carefully investigate the structural and finish conditions affecting the work and take such steps as may be required to meet such conditions.
- B. Install all piping close to walls, ceilings and columns so piping will occupy the minimum space. Provide proper space for covering and removal of pipe, special clearances, and for offsets and fittings.
- C. Install piping as to not obstruct any equipment or architectural access doors.

3.4 ISOLATION VALVES

- A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving equipment, and at other locations as indicated and required for isolation of piping or equipment.
- B. At air handling units, where multicoil (stacked) arrangement is used, provide each supply and return line to and from each stacked coil section with a union, pressure gauge and thermometer well and a balancing valve (with memory stop) for balancing, and valves for isolation of each coil. Refer to mechanical details for additional requirements.

3.5 DRAIN VALVES AND VENTS

- A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained.
- B. Install 2 inch drain for 2 -inch pipes and larger.
- C. Install a line size drain valve for pipes smaller than 2 inches.
- D. Provide hose adapter and cap on all drain lines.

- E. Provide automatic vents with isolation valves or manual vents at locations as indicated on Drawings and all high points in piping systems.

3.6 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to the above referenced specification section. Refer to drawings for additional requirements.

3.8 CONNECTIONS TO EQUIPMENT FURNISHED BY OTHERS

- A. Provide service connections to items of equipment furnished by others:
 - 1. Detailed shop drawings of equipment shall be furnished indicated the exact number and location of rough-in points.
 - 2. Such final shop drawings may indicate adjustments in total number and exact location of rough-in points, and in equipment dimensions.
 - 3. Making adjustments to field conditions is considered a part of the work required.
- B. Roughing-In:
 - 1. When roughing-in, extend service piping to various items of equipment.

2. Temporarily terminate at proper points as indicated on detailed equipment shop drawings or as directed.
3. Do not use contract drawings accompanying specifications for rough-in locations but for pipe sizing and general routing.

C. Stop Valves:

1. Provide stop valves for each service at rough-in locations, except for drains.
2. Stop valve locations are subject to approval, and in all cases must be accessible from the same room in which the furniture or equipment is located.

3.9 CLEANING OF PIPING SYSTEMS

- A. Cleaning of piping system must be performed by the mechanical contractor. Cleaning chemicals, procedure, water testing, reporting, and consultation must be provided by a qualified water treatment company specializing in this type of work. Qualified water treatment vendor will have the following features.
1. Operating in the business of industrial water treatment for minimum 5 years.
 2. Certified to the ISO 9000 quality standard.
 3. Manufacture and deliver their own products.
 4. Provide technical specialist(s) for onsite water testing, reporting, and consultation.
 5. Have the ability to perform offsite analytical laboratory work and reporting if necessary.
- B. Acceptable vendors should include, but not be limited to the following companies:
1. ChemCal, Inc.
 2. GE Water & Process Technologies
 3. Nalco Company
- C. Minimum velocity of 10 feet per second for steel piping must be maintained in the pipes during flushing period.
1. Do not use building pumps for circulating water.
 2. Provide temporary pumps as required to achieve minimum velocities.
 3. Remove flow meters from building piping during flushing operation.
 4. Provide means (instrumentation) during flushing period to prove to the Owner that the minimum velocities are maintained in the pipes.
 5. For copper piping, maintain the flushing velocity between 3 (min) and 5 (max) feet per second. Limit temperature of water inside piping to a maximum 140°F.
- D. Submit a detailed plan for the Engineer's and Owner's review and approval describing in full detail the individual steps associated with this process before any piping is installed.
1. Refer to Submittal section above for further requirements.
- E. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide temporary connections and valves as required for cleaning, purging and circulating. Provide temporary relief valves to protect the piping system if recommended by the pipe cleaning subcontractor.

- F. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blowoff valve.
- G. Provide bypasses at the following equipment as close as feasibly possible to the equipment (no more than 10 feet total of piping at each piece of equipment) and isolate equipment as required (temporary blind flanges or similar):
 - 1. Hydronic coils
- H. Chemicals shall remove mill scale, oil, and greases as well as passivate surfaces with a protective oxide film. NOTE: All residuals of the cleaning and passivating chemicals must be totally blown-down prior to system startup.
 - 1. Alkaline cleaner/penetrant/dispersant chemical. This product must be in liquid form and capable of removing mill scale, oils, greases, debris, and by-products of construction. It shall be fed at the vendor's recommended dosage rate based on the volumes of the systems treated.
 - 2. Passivating chemical. This product must be in liquid poly-phosphate form and capable of laying down a protective oxide film on metal surfaces after treatment with the cleaning chemical. It shall be fed at the vendor's recommended dosage rate based on the volumes of the systems treated.
 - 3. Antifoam chemical. This product must be in liquid form and capable of controlling or eliminating foam in water systems.
- I. Chemical for inhibiting and controlling corrosion and deposits must be added immediately after the chemical cleaning and passivating procedure.
 - 1. Closed loop corrosion inhibitor chemical. This product must be in liquid form and impart the following active ingredients at the following dosages when fed in the Chilled Water Loop water: 1) nitrite (as NO₂) = 400-800 ppm, 2) borate = 200-400 ppm, 3) azole = 20-60 ppm. This product must impart the following active ingredients at the following dosages when fed in Heating Hot Water Loop water: 1) nitrite (as NO₂) = 800-1200 ppm, 2) borate = 400-600 ppm, 3) azole = 40-80 ppm.
- J. Circulate chemical cleaner and passivator in closed loop water piping systems to remove mill scale, grease, oil, and silt.
 - 1. Flush and drain loops to remove debris prior to using chemicals.
 - 2. Fill loops and add chemical cleaner and passivator at the dosage rates recommended by the water treatment vendor based on system volume.
 - 3. Add antifoam at the dosage rates recommended by the water treatment vendor.
 - 4. Circulate water for 24-72 hours.
 - 5. Drain and flush system.
 - 6. Dispose of circulated water with chemical residuals as per local code requirements.
 - 7. Refill and immediately charge with the proper corrosion inhibitor – based on the type of piping system – to the recommended level.
 - 8. Match chemicals presently used in other systems used by Owner if possible.
 - 9. Submit all chemicals to Owner and Engineer prior to cleaning for approval.
 - 10. Match chemicals presently used in other systems used by Owner.

11. Provide report comparing make-up water quality to the water circulated in the pipe after cleaning chemicals are removed. Report shall include the following at a minimum:
 - a. Conductivity
 - b. Ph
 - c. phosphate
 - d. Iron
- K. Special requirements, if any, are specified in the appropriate Sections for each type of piping.
- L. After systems have been flushed and cleaned; as required by specifications, provide written certification from the cleaning contractor that the systems are clean and ready for use. This shall include the water quality report comparing the make-up water to the water circulated in the piping after removal of chemicals to verify pipe condition.

3.10 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure, minimum 150 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.11 PIPING APPLICATION SCHEDULE

- A. Provide piping and fittings meeting the requirements of Part 2 as identified in the table below:

Service	Pipe Sizes	Pipe Material
Chilled Water Piping	2" and smaller	Copper or Steel
Chilled Water Piping	2-1/2" and larger	Steel
Air-vent Piping	All	Copper, Steel

END OF SECTION

SECTION 23 31 13

DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Perform Work required to provide and install ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation
- B. Section Includes:
 - 1. Rectangular ducts and fittings.
 - 2. Round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.
- C. Related Sections:
 - 1. Division 09 Section, Painting, for interior painting of metal ductwork exposed to view through grilles, registers, and other openings.
 - 2. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for testing, adjusting, and balancing requirements for metal ducts.
 - 3. Section 23 07 13, External Ductwork Insulation.
 - 4. Section 23 33 00, Ductwork Accessories, for dampers, spin-in fittings, flexible duct connections.
 - 5. Section 23 37 13, Air Devices.

1.2 DEFINITIONS

- A. Low Pressure: Up to 2 inches w.g. positive or negative static pressure and velocity equal to 1500 fpm. Constructed and tested for +2 inches W.G.
- B. Medium Pressure: Over 2 inches w.g. through 6 inches w.g. positive or negative static pressure and velocity greater than 1500 fpm. All medium pressure ductwork shall be constructed and tested for +6 inches w.g.
- C. High Pressure: Over than 6 inches w.g. positive static pressure and velocity greater than 2500 fpm.
- D. Duct Size. The supply, return and exhaust duct sizes shown on drawings are clear inside sheet metal dimensions. Include proper allowances for acoustical lining, where indicated in plans or specifications.. For acoustical return air boots, refer to additional information on detail.

1.3 GUARANTEE

- A. Guarantee all ductwork for 1 year from the date of final acceptance. The guarantee will cover workmanship, noise, chatter, whistling or vibration. Ductwork shall be free from pulsation under all conditions of operation.

1.4 CONTRACTOR COORDINATION

- A. Erect all ducts in the general locations shown on the drawing(s), but conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor to check the physical conditions at the job site and make all necessary changes in cross sections, offsets and similar items, whether they are specifically indicated on drawing(s) or not. Do not obstruct the induced air plenum opening at VAV boxes and service access spaces for VAV boxes and other equipment.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

1.5 STANDARDS AND CODES

- A. Except as otherwise indicated, sheet metal ductwork material, fabrication and installation shall comply with second edition of SMACNA HVAC Construction Standards Metal and Flexible, except where indicated otherwise. All air distribution devices (such as dampers) included in this Section shall comply with the second edition of SMACNA HVAC Construction Standards Metal and Flexible.
- B. In addition, construct ductwork and all air distribution devices to the following:
 - 1. IMC International Mechanical Code
 - 2. NFPA 90A Installation of Air Conditioning and Ventilating Systems.
 - 3. NFPA 90B Installation of Warm Air Heating and Air Conditioning Systems

1.6 SUBMITTALS

- A. Product Data
 - 1. Submit product data for each product. Refer to Section 23 00 10.
 - 2. Provide acoustical data on insulated flexible ductwork as indicated in Part 2.
- B. Delegated-Design Submittal. Include the following for each system furnished on the project.
 - 1. System name and type
 - 2. Duct system design pressure.
 - 3. Sheet metal thicknesses and materials.
 - 4. Reinforcement details and spacing.
 - 5. Seam and joint construction and sealing.
 - 6. Fittings, construction and details.
 - 7. Hangers and supports, including materials, fabrication, methods for duct and building attachment.
- C. Ductwork shop drawings. Provide CAD-generated shop drawings of mechanical rooms and building ductwork drawn at a minimum scale of ¼ inch per foot. Include the following as a minimum:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory and shop fabricated duct and fittings.
 - 3. Duct layout indicating sizes, configuration and pressure classes.

- 4. Elevations of top and bottom of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Reinforcement and spacing.
 - 7. Penetrations through fire-rated and other partitions.
 - 8. Equipment installation based on equipment being used on Project.
 - 9. Duct accessories, including access doors and panels, fire dampers and smoke dampers.
- D. Samples.
- 1. Provide a sample of all type of ductwork to Engineer and Owner for approval.
- E. Welding certificates. For duct welders including procedures and standards of acceptance

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Spiral Ductwork. Gowco, McCorvey, United McGill, Lindab (supply duct only).
- B. Sheet Metal Products. McCorvey Sheet Metal Works, Gowco, United McGill, Flexmaster
- C. Insulated Flexible Duct. Pepertree Air Solutions, Thermaflex, Flexmaster.

2.2 APPLICATION

- A. Ductwork shall be constructed in accordance with the following as a minimum. Refer to drawings for any deviations from this table.

SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION ⁽¹⁾
Supply Systems:		
Untreated outside air intake, louver to FCU plenum	Galvanized Steel	Low Pressure
All ductwork downstream of fan coil units	Galvanized Steel	Low Pressure
All fan coil unit supply ductwork	Galvanized Steel	Low Pressure
Connection to Air Device	Flexible Duct	As Specified
Return Systems:		
Return air boot/transfer duct	Galvanized Steel	Low Pressure
Return air device to return distribution ⁽⁴⁾	Galvanized Steel	Low Pressure ⁽⁵⁾
Return Air Distribution	Galvanized Steel	Medium Pressure ⁽⁵⁾

- B. Notes to Table:
- 1. Positive pressure unless noted otherwise in Table.
 - 2. From air handling unit (AHU) to terminal boxes.
 - 3. From pretreatment AHU to AHU.

4. Runout from air device to return/exhaust air trunk duct
5. Negative pressure SMACNA table.

2.3 DUCT MATERIAL AND CONSTRUCTION

- A. General. Noncombustible or conforming to requirements for Class I air duct materials or UL 181. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein
- B. Galvanized Steel Ducts. Constructed of G-60 coated galvanized steel meeting requirements of ASTM A 653 or ASTM A 527. Stencil coils of sheet steel throughout on 10 foot centers with gage and manufacturer's name. All materials associated with the duct system shall be galvanized steel including stiffeners, fasteners, etc.
- C. Fasteners. Rivets, bolts or sheet metal screws.
- D. Sealant.
 1. Sealant shall be water based, latex UL 181B-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be similar to Foster 32-19, Childers CP-146, Hard Cast Iron Grip 601, Ductmate Pro Seal or Design Polymerics DP 1010.
 2. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count.
- E. Hangers and Supports.
 1. Support ductwork with continuously threaded hanger rods of galvanized steel or 20 gage straps as indicated in these specifications.

2.4 RECTANGULAR DUCTS AND FITTINGS GENERAL REQUIREMENTS

- A. General Fabrication Requirements: Comply with SMACNA based on indicated static-pressure class unless otherwise indicated. In no case shall the ductwork be less than 26 gage for low pressure ductwork, 24 gage for medium pressure ductwork.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Snaplock longitudinal seams (L2) are not acceptable.
- D. Fittings:
 1. Select types and fabricate according to SMACNA Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.

2. Construct bends and elbows per SMACNA Figure 2-2, "Rectangular Elbows", Type RE1 with radius of not less than 1-1/2 times width of duct on centerline. Where not possible or where indicated on construction documents, construct Type RE2 rectangular elbows with welded-in-place double wall airfoil turning vanes (whether specifically shown on drawings or not), or short radius type RE1 radius elbows.
3. Construct tees per SMACNA Figure 2-5, "Divided Flow Branches", Type 2, Type 3, Type 4A or 4.
4. Construct branch connections per SMACNA Figure 2-6, "Branch Connection". Use 45 degree entry, 45 degree lead in, conical or bellmouth connections only.
5. Unless indicated on construction document details, transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence. Divergence upstream of equipment shall not exceed 30 degrees. Convergence downstream of equipment shall not exceed 45 degrees.
6. Bullhead tees are not permitted.

2.5 ROUND AND OVAL DUCTS AND FITTINGS GENERAL REQUIREMENTS

- A. General Fabrication Requirements: Comply with SMACNA Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated. In no case shall the ductwork be less than 26 gage.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Use flanged joints for ducts larger than 48 inches in diameter.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Utilize spiral seam or butt weld seams only. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
- D. Fittings:
 1. Fittings shall have a wall thickness not less than that specified for longitudinal-seam straight duct or 26 gage, whichever is more stringent.
 2. Tees and Laterals: Select types and fabricate according to SMACNA Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Utilize 90 degree tee with oval to round tap, 45 degree lateral tap, or conical fitting only. Wye fittings may be utilized where specifically indicated on drawings and details.
 3. Elbows: Construct elbows with radius of not less than 1-1/2 times width of duct on centerline. Provide minimum 5 gore elbows on all 90 deg elbows, 3 gore elbows on 45 degree elbows. Continuously welded stamped long radius elbows may be utilized on ductwork up to and including 12-inches in diameter.
 4. Bullhead tees are not permitted.

2.6 INSULATED FLEXIBLE DUCTWORK

- A. Use for connection to diffusers, grilles and terminal boxes as indicated in specifications and details.
- B. Construct the inner liner of coated steel helix and a PE or CPE liner substantially bonded together to prevent the duct from collapsing or kinking in short radius bends. Provide

fiberglass insulation providing minimum R-4.2 thermal conductance and 3 pound minimum density around inner jacket consisting of fiberglass reinforcement and aluminum foil vapor barrier outer jacket. Use duct rated at minimum working pressure of 10 inches of water positive and 1 inches of water maximum negative pressure (4-12 in I.D.), and 6 inches of water positive and 1/2 inch of water maximum negative pressure (14- 16 I.D.),. Provide duct listed by U.L. at flame spread rate of not over 25 and smoke developed rate of not over 50, and complying with NFPA Standard 90A and 90B. The entire assembly shall be listed by Underwriters Laboratories under U.L. Standard 181 as a Class I flexible air duct. Supplier shall submit laboratory test results indicating acoustical performance comparable to that of "Flexmaster Type 1M-Insulated".

2.7 INTERNAL ACOUSTIC DUCT LINING

- A. Internal insulation with JohnsManville Permacote Linacoustic standard fiberglass duct liner with factory-applied edge coating. Insulation shall have a composite, abrasion resistant airstream surface with EPA-registered, anti-microbial coating that will not support microbial growth.
- B. Duct Lining used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B.
- C. Provide insulation thicknesses as follows:
 - 1. Provide 1/2 inch insulation on all return air transfer ductwork as shown on detail.
 - 2. Additional areas specifically noted on drawings.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Construction Standards. Use construction methods which follow the requirements outlined SMACNA publications, as well as SMACNA Balancing and Adjusting publications, unless indicated otherwise in these specifications or accompanying drawings.
- B. Reinforcement. Reinforce ducts having one side equal to 25 inches or more in accordance with recommended construction practice of SMACNA.
- C. Plenum Construction. Construct plenum chambers of not less than No. 20 U.S. gage metal reinforced with galvanized structural angles.
- D. Cross Breaking or Beading. Cross break or bead sheet metal for rigidity, except ducts which are 12 inches or less in the longest dimension.
- E. Wall and Floor Penetrations.
 - 1. Install fire, smoke and combination fire smoke dampers in floor penetrations and in one and two-hour rated walls where indicated in drawings and in accordance with Specification 23 31 33.
 - 2. Where ducts pass through walls in exposed areas, install suitable escutcheons made of galvanized sheet metal angles as closers.
 - 3. At all locations where ductwork passes through floors, provide watertight sleeves projecting 3 inches above finished floor and flush with bottom of floor slab.

- Fabricate sleeves of 1/8 inch thick steel, galvanized after fabrication. Anchor into adjacent floor slab as required.
4. Sleeves are required inside as well as outside chases.
 5. Provide 24 gage sheet metal sleeves for insulated [and non-insulated] ducts penetrating gyp board and CMU walls. Seal openings between ducts and sleeves with fireproofing sealants.
- F. Interior Painting. Interior painting of metal ductwork exposed to view through grilles, registers, and other openings is specified in the Section on painting. Do not install grilles, registers, or similar items until painting is complete.
- G. Ductwork Openings. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- H. Ductwork Location. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities, including access to electrical and control panels.
- I. Instrument Test Hole Fitting. Provide Duro Dyne Model TH-1 instrument test ports with heavy-duty zinc-plated heavy-gage cap, instant-release wing nut, neoprene expansion plug, flat neoprene mounting bracket and mounting holes. Provide fittings to air balance contractor.
- J. Provide transitions at equipment and air device connections as per SMACNA standards. Where equipment requires an oval inlet and a round flex duct is routed to the equipment, provide insulated round to oval transition.
- K. Install duct mounted electric and hot water coils, provided in other specification sections, if required.
- L. Refer to mechanical details for information on terminal box connections, diffuser connections, fume hood connections, lab-trac equipment, etc.

3.2 SEAM AND JOINT SEALING

- A. All duct systems (except welded exhaust ductwork and double wall flue) shall be sealed. Duct shall be thoroughly cleaned prior to application of sealant. All transverse joints, longitudinal seams and duct wall penetrations shall be sealed. All ductwork shall be sealed as per seal Class A of SMACNA Standards irrespective of the duct pressure classifications

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports." Unless indicated otherwise in specifications.

- B. Hanger Spacing. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing. Install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection. Do not use wire to support ductwork.
- C. Horizontal Ducts Up to 40 Inches. Support horizontal ducts up to and including 40 inches in their greater dimension by means of No. 20 U.S. gage band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened to inserts with toggle bolts, beam clamps or other approved means. Use clamps to fasten hangers to reinforcing on sealed ducts.
- D. Vertical Ducts. Support ducts to ensure rigid installation. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Fig. 4-7, Fig 4-8, Fig 4-9 "Riser Supports – From Floor". Support vertical ducts where they pass through the floor lines with 1-1/2 inches x 1-1/2 inches x 1/4 inch angles for ducts up to 60 inches. Above 60 inches, the angles must be increased in strength and sized on an individual basis considering space requirements. Support vertical duct drops more than 6 feet in length with angle iron frames attached to ducts.
- E. Refer to drawings for additional hanger details and requirements. Note that not all hangers are shown on the drawings are in the BIM model. The Contractor shall coordinate all hangers with the structure and other trades.

3.4 FLEXIBLE DUCTWORK

- A. Low Pressure Flexible Ductwork
 1. Do not exceed 6 feet in length with any flexible duct.
 2. Flexible duct shall be limited to a maximum of a single 90 degree change in direction between the duct and the neck of the air device. This does not include the final turn into the neck of the air device.
 3. Support ductwork independently of lights, ceiling and piping. Provide harness at connection to ceiling diffuser as indicated on details.
 4. Provide two nylon panduits or stainless steel work clamps on inner core and seal connection with duct sealant. The insulation and outer jacket shall be slipped over inner core connection to point where insulation abuts insulation on duct or diffuser. The insulation connections shall be sealed by embedding scrim tap and sealant to form a vapor barrier.
- B. Medium Pressure Flexible Ductwork
 1. Refer to details for maximum length of flexible ductwork upstream of terminal box.
 2. Do not use flexible ductwork for changes in direction of airflow.
 3. Provide two stainless steel work clamps on inner core and seal connection with duct sealant. The insulation and outer jacket shall be slipped over inner core connection to point where insulation abuts insulation on duct or terminal box. The insulation connections shall be sealed by embedding scrim tap and sealant to form a vapor barrier.

3.5 FLASHING

- A. Where ducts pass through roofs or exterior walls, provide suitable flashing to prevent rain or air currents from entering the building. Provide flashing not less than No. 26 gage stainless steel or 16 ounce copper.

3.6 DUCT LINING

- A. Fiberglass acoustical lining is not permitted to be installed on this project except as indicated in this specification or specifically shown on drawings.
- B. Install per manufacturer's recommendations. Keep internal lining clean during construction by keeping ends of ductwork sealed during storage and construction.

3.7 TESTS

- A. Allowable Leakage. Test ductwork for leaks in accordance with SMACNA before concealing or insulating as indicated below. Arrange for the Owner's Representative to witness the test.
 - 1. Low pressure ductwork. Test low pressure ductwork at +3 inches W.G. Maximum allowable leakage (Lmax) per 100 ft² of ductwork shall be equal to $C_L \times P^{0.65}$, where $C_L = 6$ for rectangular ducts and round flexible ducts, $C_L = 3$ for round/flat oval ducts, and $P = 3''$ for low pressure ducts.
 - 2. Medium pressure ductwork. Test medium pressure ductwork at +6 inches W.G. Maximum allowable leakage (Lmax) per 100 ft² of ductwork shall be equal to $C_L \times P^{0.65}$, where $C_L = 6$ for rectangular ducts and round flexible ducts, $C_L = 3$ for round/flat oval ducts, and $P = 6''$ for medium pressure ducts.
 - 3. Lab exhaust ductwork. Test laboratory exhaust ductwork at +6 inches w.g. Maximum allowable leakage is 1/2% of the total system air flow rate. Where partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
 - 4. Test the following ductwork:
 - a. Low pressure ductwork:
 - 1) All ductwork served by fan coil units.
- B. Equipment. Provide equipment necessary for performing tests, including rotary blower, orifice section and U-tube gage board complete with cocks and rubber tubing.

3.8 CLEANING

- A. Protect all ductwork and equipment from dirt during storage, installation and prior to grille, diffuser installation with protective covering at each end. Ductwork exposed to dirt and dust due to inadequate protection will have to be removed, cleaned and reinstalled.
- B. Do not operate any air handling units or fan coil units during construction without filters.
- C. Provide temporary filters on return air ductwork during construction to protect ductwork from dust.
- D. Provide temporary filters on exhaust grilles during construction to protect ductwork from dust.

END OF SECTION

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fire dampers.
 - 2. Volume control dampers.
 - 3. Duct access doors.
 - 4. Conical spin-in fittings and taps
 - 5. Duct accessory hardware.
 - 6. Flexible Connection

1.2 RELATED WORK

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specification 23 31 13, Ductwork

1.3 SUBMITTALS

- A. Product Data: Submit product data for each product. Refer to Section 23 00 10.
- B. Fire and Combination Fire/Smoke Damper. Include manufacturer's literature to include performance data and installation requirements. Include any wiring diagrams.
- C. Access Doors. Include type of material, installation guidelines, leakage rates and maximum pressure data.
- D. Volume Control Dampers. Include type of material, installation guidelines, pressure drop and maximum pressure data.
- E. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control damper installations.
 - d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
 - e. Wiring Diagrams: For power, signal, and control wiring.

1.4 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Fire dampers, smoke dampers and combination fire/smoke dampers.
 - 1. Include operation and maintenance information, including recommended testing requirements.
 - 2. Assign identification numbers (FD – Fire Damper, FSD – Fire/smoke Damper, SD – Smoke Damper) for each damper. Include table in O&M manual that indicates identification number, room location, duct system and size.

1.5 QUALITY ASSURANCE

- A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
 - 2. AMCA 500-D, "Laboratory Method of Testing Dampers for Rating"
 - 3. NFPA 101 - Life Safety Code.
 - 4. SMACNA - HVAC Duct Construction Standards Metal and Flexible – Second Edition
 - 5. UL 555 – Standard for Fire Dampers.
 - 6. UL 555C – Standard for Ceiling Radiation Dampers.
 - 7. UL 555S – Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Fire, Smoke and Fire/Smoke Dampers. Greenheck, Pottorff, Ruskin, Nailor.
- B. Flexible Connections. Ductmate, Ventfabrics Ventglass.
- C. Duct Access Doors. Ductmate, Flexmaster, Greenheck, Ruskin, United McGill.
- D. Roof Duct Supports. Portable Pipe Hangers, MAPA Products.
- E. Conical Spin-in Fittings. Flexmaster, Buckley
- F. Volume Control Dampers. Flexmaster, Greenheck, Prefco, Ruskin.

2.2 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316L, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

- D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

2.3 FIRE DAMPERS (FD)

- A. Quality Standards. Furnish and construct fire dampers according to NFPA 90A and UL 555 (Dynamic). Dampers must bear UL label and suitable for dynamic application. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165 degrees F fusible link.
- B. Construct fire dampers such that damper frame material and curtain material are galvanized.
- C. Use Curtain Type Fire Dampers for fire dampers where possible. Use Multiple Blade Fire Dampers for fire damper sizes that exceed manufacturer's allowable Curtain Type Fire Damper sizes, or where velocities or pressures exceed Curtain Type Fire Dampers.
- D. Curtain Type Fire Dampers (Type B)
 - 1. Damper shall be classified for dynamic closure to 2000 fpm and 4 inches w.g. static pressure.
 - 2. Damper shall have 5" frame constructed from minimum 20 gage galvanized steel.
 - 3. Blades shall be minimum 24 gage galvanized steel.
 - 4. Closure springs shall be Type 301 stainless steel, constant force or spring clip type.
 - 5. Provide Grille, Grille Access Type or Out of Wall Type of frame where indicated on drawings.
- E. Multiple Blade Fire Damper
 - 1. Dampers shall be suitable for dynamic closure to 3000 fpm and 6 inches w.g. static pressure at 90"x64" for vertical installation and 60"x48" for horizontal installation.
 - 2. Damper shall have 5" frame constructed from minimum 16 gage galvanized steel channel and reinforced at the corners.
 - 3. Blades shall be 6" wide airfoil type and constructed from minimum 14 gage galvanized steel.
 - 4. Bearings shall be self-lubricating stainless steel sleeve, turning in extruded hole in frame.
 - 5. Blade seals shall be galvanized steel for flame seal to 1,900 degrees F and mechanically attached to blade edge.
 - 6. Linkage shall be concealed in frame.
 - 7. Provide 1/2-inch diameter plated steel hex shaped axle attached to blade.
 - 8. Pressure drop shall be a maximum of 0.07 inches w.g. at 1,500 feet per minute through 24 x 24 inch damper.

2.4 VOLUME CONTROL DAMPERS

- A. Provide volume dampers in round and rectangular ductwork where indicated on drawings.

- B. General Fabrication Requirements:
1. Comply with SMACNA Chapter 2, "Volume Dampers" unless more stringent requirements are indicated. Provide single blade dampers on round dampers and for rectangular dampers not exceeding 36-inches in width or 12-inches in height. Provide multiblade rectangular dampers for dampers exceeding 36-inches in width or 12-inches in height or where required due to velocity or pressure requirements.
 2. Refer to Specification 23 31 13 Ductwork for application table that defines Low and Medium Pressure ductwork.
 3. Provide a locking hand quadrant on all dampers. Mount quadrant regulators on stand-off mounting brackets, bases, or adapters on insulated ducts.
 4. For stainless steel ductwork, provide stainless steel finish to match ductwork material.
 5. Shop fabricated dampers are not acceptable.
- C. Round Dampers.
1. Low Pressure. Provide single blade damper with minimum 20 gage galvanized steel frame, minimum 20 gage galvanized steel blade, continuous 3/8" square plated steel axle mechanically attached to blade, and bronze or oilite bearings. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 2"W.G. when closed, and a maximum pressure drop of 0.03"W.G. at 1500 feet per minute through a 20-inch damper when tested in accordance with AMCA Fig. 5.3.
 2. Medium Pressure. Provide single blade damper with minimum 20 gage galvanized steel frame, minimum 14 gage (equivalent) galvanized steel blade, continuous 1/2" square plated steel axle mechanically attached to blade, and bronze or oilite bearings. Dampers shall be suitable for 3000 feet per minute velocity and a maximum pressure of 4"W.G. when closed, and a maximum pressure drop of 0.06"W.G. at 2000 feet per minute through a 24-inch damper when tested in accordance with AMCA Fig. 5.3.
- D. Rectangular Dampers.
1. Low Pressure Single Blade Damper (Fans systems with less than 1"W.G. Static Pressure). Provide single blade damper with minimum 3-inch x 20 gage galvanized steel frame, minimum 20 gage galvanized steel blade on dampers up to 18-inches wide, 16 gage on dampers over 18-inches wide. Provide a continuous 3/8" square plated steel axle mechanically attached to blade, and synthetic flanged sleeve type bearing. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 1"W.G. when closed.
 2. Low Pressure Multi-Blade Damper. Provide opposed multi-blade damper with minimum 5-inch x 16 gage galvanized steel frame, minimum 16 gage triple V galvanized steel blade. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and external (out of airstream) blade-to-blade linkage. Provide bronze or oilite bearings. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 3"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.1"W.G. at 1500 feet per minute through a 24-inch x 24-inch damper.
 3. Medium Pressure Damper. Provide opposed multi-blade damper with minimum 5-inch x 1-inch 16 gage galvanized steel channel frame. Blades shall be minimum 16 gage triple V galvanized steel blade. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and external (out of airstream) blade-to-blade linkage. Provide bronze or oilite bearings. Dampers shall be suitable for 3000 feet per minute velocity and a maximum pressure of 5"W.G. for up to a 24-inch wide damper when closed. Damper shall have a

maximum pressure drop of 0.16"W.G. at 2000 feet per minute through a 24-inch x 24-inch damper when tested in accordance with AMCA Fig. 5.3.

4. Low Pressure Drop Medium Pressure Damper. Provide opposed multi-blade damper with minimum 4-inch x 1-inch 0.125-inch thick aluminum channel frame. Blades shall be extruded aluminum airfoil type, minimum 0.125-inch thick. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and linkage concealed in jamb. Provide bronze or oilite bearings. Dampers shall be suitable for 5000 feet per minute velocity and a maximum pressure of 5"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.1"W.G. at 2000 feet per minute through a 24-inch x 24-inch damper when tested in accordance with AMCA Fig. 5.3.

2.5 DUCT ACCESS DOORS

A. Square Frame Access Doors

1. Low Pressure Ductwork

- a. Construct outer frame of minimum 22 gage roll formed galvanized steel with installation tabs. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 2 manually operated cam locks on access doors 16-inches and under, 4 cam locks for doors greater than 16-inches. Provide foam gasket seal between door and frame and between frame and duct.
- b. Performance. 24"x24" access door shall be suitable for up to 2"W.G. and have a maximum leakage of 0.15 CFM/sq.ft. at 1"W.G. pressure.

2. Medium Pressure Ductwork

- a. Construct outer frame of minimum 22 gage roll formed galvanized steel with installation tabs. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 4 manually operated cam locks on access doors 16-inches and under, 8 cam locks for doors greater than 16-inches. Provide foam gasket seal between door and frame and between frame and duct.
- b. Performance. 24"x24" access door shall be suitable for up to 10"W.G. and have a maximum leakage of 0.15 CFM/sq.ft. at 1"W.G. pressure.

B. Round "Spin" Access Doors

1. Construct outer frame of minimum 22 gage roll formed, double hemmed galvanized steel. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 3 manually operated cam locks on access door. Provide continuous foam gasket between door and frame.

C. For stainless steel ductwork, provide stainless steel finish to match ductwork material.

D. Where duct size permits, access door size shall be 18-inches in diameter or 18" x 16" for oval and rectangular doors. For duct sizes under 20-inches, provide access door 2-inches smaller than duct size. For ducts 12-inches wide, provide minimum 10" x 12".

2.6 CONICAL SPIN-IN FITTINGS AND TAPS

- A. General Construction. For stainless steel ductwork, provide stainless steel finish to match ductwork material.

- B. Furnish conical spin-in fittings with quadrant dampers at all round runout ducts serving diffusers and grilles. Fabricate conical fitting of 26-gage galvanized sheet metal with 2-inch build out, continuous 3/8" square shaft, air tight nylon bushings and locking quadrant handle. Connect damper plate to shaft with a minimum 2 u-bolts on dampers 12-inches and greater.

2.7 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Drill temporary test holes for balancing in ducts as required. Cap with neoprene plugs, threaded plugs, or threaded or twist-on metal caps. Provide neat patch on external duct insulation and label as "Test Plug".
- C. Provide permanent test holes in ductwork upstream and downstream of all coils, fans, and locations as indicated on drawings. Test holes shall be factory fabricated, airtight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.8 FLEXIBLE CONNECTIONS

- A. Provide air-tight flexible connections where ductwork connects to fans, air handling units and fan coil units with fabric as specified below:

Application	Fabric	Coating	Gauge
HVAC (Indoor)	Fiberglass	Neoprene	28

- B. The fabric shall be UL listed, fire retardant, waterproof and mildew resistant, crimped into metal edging strip.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.

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

3.2 ACCESS DOORS

- A. Install duct access doors on sides or bottom of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 1. Downstream from manual volume dampers.
 2. Downstream of control dampers.
 3. Adjacent to and close enough to fire, smoke and combination fire/smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors; and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 4. At duct mounted smoke detectors.
 5. Upstream or Downstream of turning vanes.
 6. In internally lined ductwork, provide access doors for duct liner inspection at 50 foot intervals and downstream of each elbow or branch fitting. Access doors are not required in return air boots.
 7. Elsewhere as indicated on drawings, details or specifications.
- B. Label access doors according to Section 23 05 53 - Identification for HVAC Piping and Equipment to indicate the purpose of access door.

3.3 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPERS

- A. Install dampers at locations indicated on the drawings and in accordance with manufacturer's UL approved installation instructions.
- B. Install dampers square and free from racking with blades running horizontally.
- C. Do not compress or stretch damper frame into duct or opening.
- D. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jackshaft.
- E. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.
- F. Provide access doors for all fire, smoke and combination fire/smoke dampers. Refer to details for additional requirements.

3.4 CONICAL SPIN-IN FITTINGS AND TAPS

- A. Install conical spin-in fittings with quadrant dampers to serve diffusers as indicated on drawings.
- B. After installation of spin-in fitting, seal all around connection to meet leakage class indicated in Specification 23 31 13.

3.5 VOLUME CONTROL DAMPER

- A. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install

dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

- B. Set dampers to fully open position before testing, adjusting, and balancing

3.6 FLEXIBLE CONNECTIONS

- A. Install at connections between ductwork and motor driven equipment as shown. Provide a minimum of 1 inch slack in the connections, and a minimum of 2-1/2 inches distance between the edges of the ducts and equipment. Also provide a minimum of 1 inch slack for each inch of static pressure on the fan system. Securely fasten flexible connections to equipment and to adjacent ductwork by means of sealant with sheet metal screws. Where flex ductwork is connected to oval collars in diffusers and plenums, provide a metal transition fitting from oval to round.

3.7 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 1. Operate all volume dampers to verify full range of movement.
 2. Inspect locations of access doors and verify that purpose of access door can be performed.
 3. Operate fire, smoke and combination fire/smoke dampers to verify full range of movement per NFPA and verify that proper heat-response device is installed.

END OF SECTION 23 33 00

SECTION 23 34 13

FANS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for furnishing and installing fans and supplemental equipment including the following:
 - 1. Centrifugal fans.

1.2 PERFORMANCE

- A. Provide fan type, arrangement, rotation, capacity, size, motor horsepower, and motor voltage as shown. Fan capacities and characteristics are scheduled on the drawings.
- B. Rate fans according to appropriate Air Moving and Conditioning Association, Inc. (AMCA), approved test codes and procedures. Supply fans with sound ratings below the maximums permitted by AMCA standards. All fans provided must be licensed to bear the Certified Ratings Seal.
- C. Statically and dynamically balance all fans.

1.3 SUBMITTALS

- A. General:
- B. Submit shop drawings and product data.
- C. Shop drawings shall indicate assembly, unit dimensions, weight, required clearances, construction details and field connection details.
- D. Product data shall indicate capacities, ratings, fan performance, motor electrical characteristics, and gages and finishes of materials.
- E. Provide fan curves with specified operating point clearly plotted.
- F. Submit sound power levels.
- G. Submittals shall show compliance with Section 15765, AC Electric Motors.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.5 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Include installation instructions, assembly views, lubrication instructions and replacement parts list.
- C. Include copy of approved submittals (with all comments corrected).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Fans:
 - a. Acme Engineering & Mfg. Corp.
 - b. Greenheck.
 - c. Loren Cook Company.
 - d. Twin City Fan & Blower

2.2 PROTECTIVE COATINGS

- A. Manufacturer's Standard: Apply manufacturer's standard prime coat and finish to fans, motors and accessories, except on aluminum surfaces or where special coatings are required.
- B. Galvanizing:
 - 1. After fabrication of the parts, hot-dip coat all surfaces which require galvanizing.
 - 2. Where galvanizing is specified, a zinc coating may be used.
 - 3. After fabrication, apply the zinc coating and air-dry the coating to 95 percent pure zinc.
 - 4. Acceptable zinc coatings include Zincilate, Sealube, Amercoat, Diametcoat, or an approved equal.
- C. Fasteners for all fans and relief hoods mounted outside of building shall be stainless steel.

2.3 SUPPLEMENTAL EQUIPMENT

- A. Motor Covers: Provide weatherproof motor covers for installations out of doors. Apply the same finish as used on the fan.
- B. Belt Drives:
 - 1. Unless otherwise specified for belt-driven fans, equip the fan motors with variable pitch sheaves. Select the sheave size for the approximate midpoint of adjustment and to provide not less than 20 percent speed variation from full open to full closed. Size drives for 150 percent of rated horsepower. Key the fan sheave to the fan shaft.
 - 2. Nonadjustable motor sheaves may be used for motor sizes over 15 horsepower, at the Contractor's option. However, if changing a nonadjustable sheave becomes necessary to produce the specified capacity, the change must be made at no additional cost.

3. Provide belt guards and apply the same finish as used for the fan.
- C. Safety Disconnect Switch: Provide a factory-wired, safety disconnect switch on each unit equipped with a 115/1/60 motor. Division 26 will provide safety disconnect switches for all motors that are not 115/1/60, such as three phase motors, unless noted otherwise in specifications or fan schedule.
- D. Relief Vents and Air Inlets: Provide vents and inlets with aluminum frames and 1/2-inch mesh, galvanized bird screens. Include dampers, motorized dampers on inlets and adjustable counter balanced dampers for relief vents as indicated on fan schedule and in specifications.
- E. Prefabricated Roof Curbs: Furnish prefabricated roof curbs with built-in cant strips and lined with glass fiber insulation. Curbs may be made of No. 18 U.S. standard gage galvanized steel or 0.063 inch aluminum. The minimum height is 8 inches. Include on each roof curb a resilient pad for equipment mounting on the top flange. Include damper tray where indicated on schedule or specifications.
- F. Motors. All 115/1/60 motors shall be provided with thermal overload protection.
- G. Nameplates. Provide an aluminum or stainless steel nameplate secured with screws to the equipment in a location that is readable when the equipment is installed and in operation. The following information shall be included on the nameplate: manufacturer, model number, serial number, date of manufacture, Motor HP, Motor enclosure, motor volts/ph/hz and rpm, design CFM, design SP, Fan Class, Fan RPM, Max RPM.
- H. Sound Attenuating Base: Construct sound attenuating bases of No. 18 U.S. standard gage galvanized steel or 0.063 inch aluminum. Include a built-in cant strip for curb mounting and a resilient pad for equipment mounting on the top flange. Line the base with 2 inches of glass fiber insulation and fit internally with glass fiber acoustical baffles.
- I. Fan Isolation Base. Provide fan manufacturer's factory isolation base to provide support for fan and motor. The base shall be constructed of structural steel C4x4.5 channel (minimum) and coated same as specified for lab exhaust fans. All connections shall be welded. The base shall have mounting holes at each of the four corners for installation of vibration isolators.

2.4 ROOF-MOUNTED DOWNBLAST EXHAUST FANS (EF-P-1)

- A. General. Fan shall be a spun aluminum, roof mounted, belt or direct driven as indicated on schedule, downblast centrifugal exhaust ventilator.
- B. Construction. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The discharge baffle shall have a rolled bead for added strength. A two piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream.

- C. Wheel. Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05.
- D. Fan Motor, Bearings and Drives. Motor shall be NEMA design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure. Bearings shall be ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.
- E. Supply a disconnect switch on all 120V/1ph and 277/1ph fans and have the switch and motor factory wired to the junction box. Provide 120V motorized backdraft dampers with curb flanges where indicated on schedule. Provide adjustable gravity backdraft damper where indicated on schedule. Provide speed controllers on all direct drive fans. Unit shall have integral conduit chase provide through curb cap and into the motor compartment.
 - 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fans level and plumb.
- B. Support floor-mounting units using spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
 - 1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section, Cast-in-Place Concrete.
- D. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
- E. Install units with clearances for service and maintenance.
- F. Label fans according to requirements specified in Section 23 05 53, Identification for HVAC Piping and Equipment.

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00, Air Duct Accessories.
- B. Ground equipment according to Division 26 requirements.
- C. Connect wiring according to Section 26 05 19, Insulated Conductors.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

SECTION 23 37 13

AIR DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes air distribution devices including the following:
 - 1. Diffusers.
 - 2. Grilles.
 - 3. Registers.

1.2 COOPERATION WITH OTHER TRADES

- A. Coordinate work with Division 26 Electrical Sections to ensure intended functions of lighting and air systems are achieved.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples: At the request of the Owner and/or A/E team, submit each exposed product for each color and texture specified.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:
 - 1. Diffusers, Grilles and Registers. Krueger, Price, Metalaire, Titus.
 - 2. Sound Attenuators. Commercial Acoustics, , Transonics, United McGill, Price,.

2.2 DIFFUSERS

- A. Square Plaque Diffuser (MARK A – E):
 - 1. Provide aluminum plaque diffuser, precision formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct. An inner plaque assembly shall be incorporated that drops no more than 1/4 inch below the ceiling plane to assure proper air distribution performance. The inner plaque assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck.
 - 2. Finish shall be White Powder Coat.
 - 3. Provide transitions for rectangular duct connections if required.
- B. Perforated (MARK F – K):

1. Provide steel frame construction with aluminum perforated face and white factory finish. Frame the diffuser face with a mitered and welded frame.
2. Face shall have no less than 51% free area.

2.3 DIFFUSERS - PART OF A RATED CEILING ASSEMBLY

- A. Provide UL fire rated ceiling diffuser with louver face, radiation fire damper and thermal blank radiation barrier.

2.4 GRILLES

- A. Supply (MARK L):
1. Use double-deflection supply grilles made of aluminum.
 2. Install vertical face blades and horizontal rear blades. Provide solid, extruded aluminum blades which are individually adjustable. Space at not more than 3/4 inch centers for rear blades and 1/2 inch centers for face blades and not less than 5/8 inch deep.
 3. Employ grille frames of extruded aluminum with welded and mitered corners and mounting gaskets.
 4. Provide white finish on all grilles unless indicated otherwise on drawings.
 5. Provide integral **aluminum** opposed blade damper with **mill finish**.
- B. Return and Exhaust (MARK M):
1. For ceiling return, provide scheduled diffuser with white factory finish. Use construction and frame styles as specified for ceiling diffusers, but without pattern controllers. Use neck sizes as shown.
 2. For wall return and exhaust, provide a 45 degree fixed-blade aluminum grille. Provide 3/4 inch blade spacing as scheduled, with front blades parallel to long dimension. Provide solid, extruded frames and aluminum blades which are individually adjustable on sizes larger than 24 inches x 24 inches, roll-formed aluminum blades for smaller grilles. Include mounting gaskets. Provide white finish unless noted otherwise on drawings.

2.5 ACCESSORIES

- A. Supply Grille Extractors. Provide each supply grille with an air control device capable of positively regulating the volume of air extracted from the supply duct.
1. Select extractors similar to Price Model AE1, tight-closing in the minimum position. Include a key-operated or worm-gear adjusting mechanism to facilitate positioning from the grille opening. Where adjustment is not accessible at the grille opening, provide a control rod equipped with a locking quadrant.
 2. For ductwork control, use Young regulators. Provide extractors 30 inches and longer with a support rail inside of the duct at the outboard quarter point of the extractor. Construct the support rail of angle or channel members formed of sheet metal fastened securely to the duct. Make the rails 18 inches long, except where duct width prevents the extractor from sagging when moved toward its maximum position.
 3. Check extractors thoroughly for freedom of operation. If necessary, oil bearing points before installing.
- B. Mounting Frames. Provide each grille or register not equipped with a removable core with a companion, all-purpose mounting frame constructed like a grille frame to facilitate installation and removal of the grille or register without marring adjacent mounting surfaces.
1. Furnish frames with 1/2 inch thick sponge rubber gasket to prevent air leakage.

2. Provide a frame that neatly fits the grille. Mounting frames will not be required for grilles or registers mounted directly on exposed ductwork.

2.6 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 GENERAL

3.2 INSTALLATION

- A. Do not install ceilings adjacent to fixtures until installation of fixtures, air supply assemblies, return-air blank-off strips and flexible duct have been properly approved. Remove and reinstall any part of the installation found incorrect.
- B. Diffusers. Louvered diffuser outlets mount tight against the ceiling. Fasten outlets securely to ductwork with sheet metal screws. For perforated diffusers, attach the frame assembly by a concealed hinge assembly to an outer frame compatible with the type of ceiling on which the diffuser is installed.

3.3 ADJUSTING

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

END OF SECTION

SECTION 23 82 19

FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies horizontal fan coil units for concealed overhead or exposed installation.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Units shall be ARI 440 certified and labeled.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IESNA 90.1-2007 Compliance: Applicable requirements in ASHRAE/ IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

- A. Provide one (1) year manufacturer's warranty. Include coverage of fan-coil unit and motors.

1.5 DEFINITION

- A. Exposed cabinet is defined as a unit that does not have supply or return duct connections, but has integral supply and return registers.

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan-Coil-Unit Filters: Install new filters at substantial completion per Part 3 of this specification. Furnish one additional spare filters for each filter installed to be used by Owner after substantial completion.
 - 2. Fan Belts: Furnish one spare fan belt for each unit installed

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide scheduled products by one of the following:
 - 1. Greenheck
 - 2. International Environmental Corporation.
 - 3. Johnson Controls
 - 4. McQuay

2.2 DIRECT DRIVE FAN-COIL UNITS

- A. Cabinet. Construct of heavy gauge galvanized steel panels. Exposed units shall be shall be finished with a heat cured anodic acrylic powder paint of the standard factory color. All units shall be insulated with 1/2-inch, 1-1/2 pound foil faced fiberglass insulation meeting NFPA 90A requirements. Insulate coil and fan sections. Seal insulation edges.
- B. Access. Exposed units shall have fan and filter bottom access panel attached with quarter turn quick open fasteners for access to service.
- C. Fan. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. Plenum unit fan assemblies shall be easily serviced through an access panel provided.
- D. Motor. Motors shall be high efficiency, permanently lubricated sleeve bearing, permanent split-capacitor type with UL and CSA listed automatic reset thermal overload protection and three separate horsepower taps. Single speed motors are not acceptable.
- E. Hydronic Coil. 1/2 inch copper tube, 0.025-inch tube wall thickness, with mechanically bonded aluminum fins spaced no closer than 12 fins/inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220°F. Include manual air vent and drain valve.
- F. Drain Pan. Primary condensate drain pans shall be single wall, heavy gauge stainless steel for corrosion resistance, and extend under the entire cooling coil. Drain pans shall be of one-piece construction and be positively sloped for condensate removal. Drain pans on concealed models shall be field reversible for right or left hand connections. The drain pan shall be externally insulated with a fire retardant, closed cell foam insulation. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21

- G. Filters. All plenum and exposed units not ducted to the outside shall be furnished with a minimum 1" pleated MERV 6 filter. Filters shall be tight fitting to prevent air bypass. Plenum unit filters shall be easily removable from the bottom of the unit without the need for tools.
- H. Filters. All plenum and exposed units receiving ducted outside air shall be furnished with a minimum 2" pleated MERV 8 filter. Filters shall be tight fitting to prevent air bypass. Plenum unit filters shall be easily removable from the bottom of the unit without the need for tools.
- I. Electrical. Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations. The factory mounted terminal wiring strip consists of a multiple position screw terminal block to facilitate wiring terminations for the electric control valves and thermostats. Provide unit mounted three speed fan and disconnect switch.
- J. Controls: All controls, including terminal equipment controller for fan coil unit shall be supplied by Temperature Controls Contractor to fan coil unit manufacturer for factory installation.
- K. Options: Refer to FCU Schedule
 1. Provide double deflection discharge grille where indicated on fan coil unit schedule.
 2. Provide insulated mixing box with return and outside air connections.
- L. Electric Heating Coil. Furnish an electric resistance heating assembly as an integral part of the fan coil unit, with the heating capacity, voltage and kilowatts scheduled. The heater assembly shall be designed and rated for installation on the fan coil unit without the use of duct extensions or transitions, and be located in the unit as to not expose the fan assembly to excessive leaving air temperatures that could affect motor performance. The heater and unit assembly shall be listed for zero clearance and meet all NEC requirements, and be ETL listed with the unit as an assembly in compliance with UL/ANSI Standard 1995. All heating elements shall be open coil type nichrome wire mounted in ceramic insulators and located in an insulated heavy gauge galvanized steel housing. All elements shall terminate in a machine staked stainless steel terminal secured with stainless steel hardware for corrosion resistance. All internal wiring shall be rated for 105°C minimum. All heaters shall include over temperature protection consisting of an automatic reset primary thermal limit and back up secondary thermal limit. All heaters shall be single stage. Provide a manual reset secondary thermal limit.

2.3 BELT DRIVE FAN COIL UNITS

- A. General. Provide horizontal or vertical fan coil units as indicated on schedule. All units shall be of "draw-thru" design with coils, fans, motor/ drive and drain pan completely contained within the unit cabinet.
- B. Cabinet. Construct of 18-gage galvanized steel panels. Exposed units shall be finished with a heat cured anodic acrylic powder paint of the standard factory color. Units shall be insulated with 1-inch, 1-1/2 pound foil faced fiberglass insulation meeting NFPA 90A requirements. Insulate coil and fan sections. Seal insulation edges.
- C. Access. All access panels shall be fully insulated and attached with standard fasteners on at least two opposite sides. No coil or drain piping or electrical connections shall pass through any access panel.

- D. Fan. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. Fan shall have permanently lubricated ball bearings with a minimum design average life (L50) of 100,000 hours.
- E. Motor. Motors shall be high efficiency, standard NEMA design motors of the horsepower listed in the equipment schedule. All motors shall be 1750 RPM, 60 hertz single speed motors rated for continuous duty. All motors shall be reversible rotation type. Three phase motors shall be "across-the-line" start type. All motors shall be mounted on an adjustable base. All motor wiring is to be terminated in a junction box, external to the unit casing. All fan drive assemblies shall include an adjustable pitch motor pulley, a fixed pitch blower pulley and a standard cross section "V-belt". All fan drives shall be selected at a minimum service factor of 1.2.
- F. Hydronic Coil. 1/2 inch copper tube, 0.025-inch tube wall thickness, with mechanically bonded aluminum fins spaced no closer than 12 fins/inch, rated for a maximum working pressure of 300 psig and a maximum entering-water temperature of 200°F. Include manual air vent and drain valve. Provide stainless steel coil casing.
- G. Drain Pan. Primary condensate drain pans shall be single wall, heavy gauge IAQ stainless steel for corrosion resistance, and extend under the entire cooling coil. Drain pans shall be of one-piece construction and be positively sloped for condensate removal. The drain pan shall be externally insulated with a fire retardant, closed cell foam insulation. The insulation shall carry no more than a 25/50 Flame Spread and Smoke Developed Rating per ASTM E-84 and UL 723 and an Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21
- H. Filters. All units receiving ducted outside air shall be furnished with flat filter rack with hinged access on both sides, designed to accept a 2" thick filter. Provide 2" pleated MERV 8 (70%) pleated filter. Filters shall be tight fitting to prevent air bypass.
- I. Filters. All units not ducted to the outside shall be furnished with flat filter rack with hinged access on both sides, designed to accept a 2" thick filter. Provide 2" pleated MERV 6 (30%) pleated filter. Filters shall be tight fitting to prevent air bypass.
- J. Electrical. Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations. The factory mounted terminal wiring strip consists of a multiple position screw terminal block to facilitate wiring terminations for the electric control valves and thermostats
- K. Controls: All controls, including terminal equipment controller for fan coil unit shall be supplied by Temperature Controls Contractor to fan coil unit manufacturer for factory installation.
- L. Options:
 - 1. Provide mixing box where shown on schedule or drawings. Mixing box shall be fully insulated and constructed the same as cabinet.
 - 2. A main incoming power non-fused disconnect switch shall be factory furnished and wired by the unit manufacturer for single point power connection where indicated on schedule.
 - 3. Unit shall have a 12 gauge galvanized steel base rail for ceiling or floor mounting.

- M. Electric Heating Coil (where scheduled). Furnish an electric resistance heating assembly as an integral part of the fan coil unit, with the heating capacity, voltage, kilowatts and number of stages scheduled. The heater assembly shall be designed and rated for installation on the fan coil unit without the use of duct extensions or transitions, and be located in the unit as to not expose the fan assembly to excessive leaving air temperatures that could affect motor performance. The heater and unit assembly shall be listed for zero clearance and meet all NEC requirements, and be ETL listed with the unit as an assembly in compliance with UL/ANSI Standard 1995. All heating elements shall be open coil type nichrome wire mounted in ceramic insulators and located in an insulated heavy gauge galvanized steel housing. All elements shall terminate in a machine staked stainless steel terminal secured with stainless steel hardware for corrosion resistance. All internal wiring shall be rated for 105°C minimum. All heaters shall include over temperature protection consisting of an automatic reset primary thermal limit and back up secondary thermal limit. Provide a manual reset secondary thermal limit and airflow switch. Units shall have single point power connection with fused disconnect switch.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fan-coil units to comply with NFPA 90A.
- B. Suspend fan-coil units from structure with vibration isolators as specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
- C. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation.
- D. Install new filters in each fan-coil unit at Substantial Completion.
- E. For units located above ceilings, provide a 22 gage galvanized steel auxiliary drain pan mounted below the entire unit and primary drain pan. Pipe auxiliary drain as indicated on details. Temperature Controls Contractor to install a float switch to alarm and shut-down fan coil unit upon sensing of water.
- F. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.
- G. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Section 23 33 00, Air Duct Accessories. Comply with safety requirements in UL 1995 for duct connections.

3.2 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:

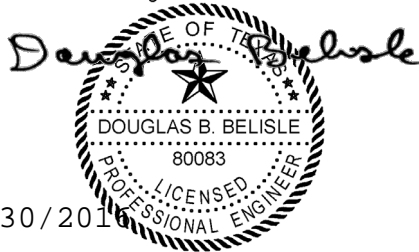
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

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SECTION 26 05 00

ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide labor, materials and equipment required for complete and functioning electrical systems as required by the contract documents.
- B. New Work. The work includes, but is not limited to, the following principal systems and equipment:
 - 1. Medium Voltage distribution (>1000V).
 - 2. 480/277 volt distribution.
 - 3. 208/120 volt distribution.
 - 4. Switchgear.
 - 5. Panelboards-Distribution, Branch Circuit and Electronic Grade.
 - 6. Transformers.
 - 7. Luminaires, lamps and ballasts.
 - 8. Fire alarm system.
 - 9. Lighting controls.
 - 10. Grounding and bonding system.
 - 11. Motor controllers.
 - 12. 13. Electric motors. Furnished and installed by Divisions 21, 22 and 23. Electrical connections by Division 26.
- C. Demolition. Refer to plans for scope of work.

1.2 APPLICABLE PROVISIONS

- A. Provisions Specified Elsewhere. Unless modified in this Section, General and Supplementary General Conditions, applicable provisions of Division 01 - General and other provisions of contract documents apply to work of Division 26 - Electrical.
- B. Application. Provisions of this Section apply to every section of Division 26 - Electrical, except where specifically modified.
- C. Work covered by this Section shall be accomplished in accordance with applicable provisions of the Contract Documents and addenda or directives which may be issued herewith, or otherwise.

1.3 RELATED WORK

- A. Existing Conditions - Division 02.
- B. Openings - Division 08.
- C. Specialties - Division 11.
- D. Fire Protection – Division 21.

- E. Plumbing – Division 22.
- F. Heating, Ventilation and Air Conditioning – Division 23.

1.4 REFERENCE CODES AND STANDARDS

- A. Standards of the following organizations may be referenced in the specification. Unless noted otherwise, references are to standards or codes current at the time of bidding.
- B. Association of Edison Illuminating Companies (AEIC).
- C. American National Standards Institute (ANSI).
- D. Institute of Electrical and Electronics Engineers (IEEE).
- E. Insulated Cable Engineers Association (ICEA).
- F. National Electrical Code (NEC).
- G. National Electrical Manufacturers Association (NEMA).
- H. National Electrical Safety Code (NESC).
- I. National Fire Protection Association (NFPA).
- J. Underwriters' Laboratories (UL).
- K. ASHRAE/IESNA 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.5 REGULATIONS AND PERMITS

- A. Regulations. Work, materials and equipment must comply with the latest rules and regulations of the following:
 - 1. National Electrical Code (NEC).
 - 2. National Electrical Safety Code (NESC).
 - 3. Occupational Safety and Health Act (OSHA).
 - 4. Americans with Disabilities Act (ADA).
 - 5. Texas Department of Licensing and Regulation (TDLR).
 - 6. Texas Occupational Code.
 - 7. Texas Electrical Safety and Licensing Act – Title 8, Occupations Code Chapter 1305.
 - 8. State and federal codes, ordinances and regulations.
- B. Discrepancies. The drawings and specifications are intended to comply with listed codes, ordinances, regulations and standards. Where discrepancies occur, immediately notify the Owner's representative in writing, including a proposed resolution, and ask for an interpretation. Should installed materials or workmanship fail to comply, the Contractor is responsible for correcting the improper installation. Additionally, where sizes, capacities, or other such features are required in excess of minimum code or standards requirements, provide those specified or shown.
- C. Permits: Obtain certificates of inspection and other permits required as a part of the work. Submit written evidence to the Owner's Representative and Architect/Engineer that the required permits and inspections have been secured.

1.6 DRAWINGS AND CONTRACT DOCUMENTS

- A. Intent: The intent of the construction Drawings or contract documents, hereinafter referred to as the "Drawings", is to establish the types of systems and functions, but not to set forth each item essential to the functioning of the system. The Drawings, specifications, and related contract documents are cooperative, and work or materials called for in one and not mentioned in the other shall be provided. Electrical Drawings, are generally diagrammatic and show approximate location and extent of the work. Review pertinent Drawings and adjust the work to conditions shown. Install the work complete, including minor details necessary to perform the function indicated.
- B. The Contractor shall carefully investigate structural and finish conditions, and shall coordinate the work in order to avoid interference between the various phases of work. The Contractor shall be responsible for the proper routing of raceways, subject to prior review by the Owner's Representative. Work shall be organized and laid out in finished portions of the building so that it will be concealed in furred chases, suspended ceilings, and similar elements of the building, unless specifically noted to be exposed. Work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.
- C. Discrepancies: In case of doubt as to work intended, or if amplification or clarification is needed, or where discrepancies occur between Drawings, specifications, and actual field conditions, immediately notify the Architect/Engineer and the Owner's Representative in writing, requesting an interpretation, and include a proposed solution.
- D. Dimensions: Dimensional information related to new structures shall be taken from the appropriate Drawings. Dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the site.
- E. Outlet and Equipment Locations: Coordinate the actual locations of electrical outlets and equipment with building features and equipment as indicated on architectural, structural, mechanical, telecommunications, audio-visual (AV), security, plumbing, and laboratory Drawings. Review with the Owner's Representative proposed changes in outlet and equipment location. Relocation of outlets before installation of up to 5 feet from the position indicated may be directed without additional cost to the Owner. Remove and replace outlets placed in unsuitable locations, when so requested by the Owner's Representative, and at no additional cost to Owner.

1.7 SUBMITTALS

- A. Submit the following in addition to and in accordance with the requirements of the Uniform General Conditions and in Division 01, Submittals.
 - 1. Include inspection and permit certificates and certificates of final inspection and acceptance from the authority having jurisdiction.
 - 2. Manufacturer's standardized schematic diagrams and catalog cuts shall not be acceptable unless applicable portions are clearly indicated and non-applicable portions clearly deleted or crossed out.
 - 3. Schematic, connection and/or interconnection diagrams.
 - 4. Provide submittals as required by individual specification section.
- B. Provide the following with each submittal:
 - 1. Catalog cutsheets with manufacturer's name clearly indicated. Applicable portions shall be clearly indicated by arrows, circles, or similar markings and non-applicable portions shall be clearly deleted or crossed out.
 - 2. Line-by-line specification review by equipment manufacturer and contractor with exceptions explicitly defined.

3. Itemize and organize equipment and material submittals by specification Section number; include manufacturer and identifying model or catalog numbers.
 - a. Submittal packages for product data, shop drawings, and other required submittals shall be numbered sequentially according to the applicable specification Section number. For example, the first submittal package for Energy-Efficient Dry-Type Transformers shall be identified as Submittal number 262213-01. The second submittal package for Energy-Efficient Dry-Type Transformers would be identified as Submittal number 262213-02. Re-submittal packages shall be identified by an "R" in the sequential numerical suffix.
 - b. Where directed by the Owner or the Architect to combine submittals into a common package, the submittal data may be organized in one or more 3-ring binders or similar container. Product data, shop drawings, and other submittal data shall be organized in separate tabs according to paragraph 1.07B.3a, above. That is, submittal data in individual tabs of a common submittal package shall be numbered sequentially, according to the applicable specification Section number.
 4. Replace rejected items and resubmit with acceptable items in accordance with the requirements of Division One for Submittals, and with the Uniform General Conditions.
- C. Within the specified time window after award of contract, submit list of equipment and materials to be furnished.
1. Itemize equipment and material by specification section number; include manufacturer and identifying model or catalog numbers.
 2. Replace rejected items with an acceptable item within 2 weeks after notification of rejection.
 3. If a satisfactory replacement is not submitted within a two-week period, Owner will notify contractor as to equipment manufacturer or type and make or material to be furnished. Provide designated items at not additional cost to Owner.
- D. Equipment Layout Drawing: 1/8-inch scale minimum drawings indicating all new electrical equipment locations. Dimensions for all equipment shall be indicated on these drawings including dimensions from equipment to walls/pipes. Indicate routing of conduit 2 inches and over on these drawings. Also clearly shows the new steel support system.
- E. Coordination Drawings: The Contractor shall prepare one complete set of composite drawings. The shop drawings for sheet metal ductwork shall be used as the basis for this coordination in addition to any existing ductwork & piping. Exact size and locations of piping and ductwork shall be field verified and shown on these plans. When the sheet metal drawings have been prepared, the raceway, luminaires, mechanical piping, plumbing piping, and fire protection piping shall be overlaid and drafted onto the composite drawing. The intent of this process is to define areas of potential conflict and resolve those conflicts prior to fabrication or installation of work. In areas of congestion (where simply overlaying and drafting will create an unreadable product), the plan view scale shall be increased and multiple layered views shall be developed. Elevations of the individual elements shall be established, and elevations shall be drawn to illustrate that the ductwork, piping, raceway, and other systems and components will co-exist within the available space, and that the proper access to equipment, luminaires, valves, filters, etc. has been established for operation, service, removal and replacement. In addition to the above, the Contractor shall also submit the following for review:
1. Electrical Rooms. Submit 1/4-inch scale coordination drawings of electrical rooms indicating location of equipment. Indicate the exact location of each component in relation to other existing and new mechanical, electrical, and plumbing (MEP) components within each room. Include location(s) and quantity of raceway(s) and

- sleeve(s) stubbed up through floor slab for power, lighting, control, grounding, communications, and low-voltage system(s). These coordination drawings shall take into account the configuration of the mechanical, electrical, and telecommunications equipment which has been proposed and approved for use in the project, particularly where it differs in configuration from the equipment shown on the Drawings. .In gym area and handball court where new electrical equipment is being located, the coordination drawings shall clearly show the new metal platform, all equipment dimensions and dimensions to all walls and existing pipes etc.
2. Mechanical and Pump Rooms. Submit 1/4-inch scale coordination drawings of mechanical and pump rooms indicating location of electrical equipment. Indicate the exact location of each component in relation to other MEP components within each mechanical and pump room. These coordination drawings shall take into account the configuration of the mechanical and electrical equipment which has been proposed and approved for use in the project, particularly where it differs in configuration from the equipment shown on the Drawings.
 3. Building Information Modeling (BIM). Where a BIM-model of the project has been developed by the Architect/Engineer or Contractor, the BIM model may be used to develop and produce the coordination drawings. The Contractor and the individual trades shall confirm in writing that the BIM-model and related coordination drawings accurately match the components and systems to be fabricated and installed.
 4. Review: The completed "Composite Drawings" shall be submitted to the Architect/Engineer for review prior to installation. Work that proceeds without appropriate coordination and review will be subject to removal and relocation at no additional cost to the Owner.
- F. Installation: Where product data or shop drawings are required, do not install equipment or materials until submittals are accepted by the Architect/Engineer and by Owner's Representative. Use only equipment and materials accepted by the Architect/Engineer and by Owner's Representative. Equipment and materials installed prior to acceptance by the Owner/Engineer and Owner's Representative shall be removed at no additional cost to Owner and replaced at the Contractor's expense.
- G. Startup and Test Procedures:
1. Furnish documentation from equipment manufacturer for the startup and field testing procedures for equipment installed as a part of this project.
 2. Startup and testing procedures shall include prerequisite conditions, system and equipment alignments and lineups, sequential steps for execution of the test, shutdown procedures, and criteria for satisfactory test completion and test failure.
 3. Startup and testing procedures shall address and demonstrate modes of system or equipment operation, including startup, manual, unattended/automatic, and shutdown procedures, as well as procedures for testing and demonstration of abnormal or emergency operating conditions.
 4. Include forms and logs to be used during field testing. Forms and logs shall include the range of permissible values for monitored parameters, as applicable.
- H. As-Built and Record Drawings:
1. Maintain a master set of as-built drawings that show changes and other deviations from the Drawings. The markups must be made as the changes are done.
 2. At the conclusion of the project, these as-built drawings shall be transferred to AutoCAD electronic files, in a format acceptable to the Owner's Representative, and shall be complete.
 3. Prior to final acceptance, deliver to the Owner's Representative the AutoCAD electronic files, the complete set of record drawings showing the as-built condition of the project, and the actual field set of as-built drawings. Also deliver one set of as-

built drawings on CD-Rom or similar electronic media acceptable to the Owner. Drawing files shall be in AutoCAD (.dwg) and Adobe Acrobat (.pdf).

4. Quantity: In accordance with the requirements of Division One and the General Conditions. Where not specified elsewhere, provide 3 hard copies plus one reproducible set.
 - I. Operating and Maintenance Manuals: As specified in Part 3 of this Section and in Division One, as applicable.
 - J. Overcurrent Protective Device Coordination Study: Provide preliminary and final study as specified in Section 26 05 73. Make adjustments to materials and submittals under other Sections of Division 26 as required and as recommended by the Overcurrent Protective Device Coordination studies.

1.8 SUBSTITUTIONS

- A. Refer to requirements of Division One for substitution of Material and Equipment.
- B. Product manufacturers are listed to establish a level of quality for the products. Substitutions may be allowed if the product is equal to or better than what is listed in the design guidelines, as determined by the Architect/Engineer and owner's Representative upon submittal of comparison products.
- C. Samples: When requested by the Owner's Representative or the Architect/Engineer, the Contractor shall provide a sample of the proposed substitute item. When requested, provide samples of both the specified item and the proposed item for comparison purposes.
- D. Timeliness: The burden of timeliness in the complete cycle of submittal data, shop drawings, and sample processing is on the Contractor. Time periods for Architect/Engineer processing and review of submittal data, shop drawings, samples, studies, and reports shall be in accordance with the applicable submittal and substitution requirements of Division One and the General Conditions. The Contractor shall allow sufficient time for review of each submission by the office of the design discipline involved after receipt of such submissions by that design discipline. The Contractor is responsible for allowing sufficient time in the construction schedule to cover the aforementioned cycles for processing of submittal data and shop drawings, including time for resubmittal cycles on unacceptable and rejected materials, equipment, components, and systems covered by the data submitted. Construction delays and lack of timeliness in the above regard are the responsibility of the Contractor and will not be considered in requests for scheduled construction time extensions and additional costs to the Owner.
- E. Acceptance: Acceptance of materials and equipment will be based on manufacturer's published data and will be tentative subject to the submission of complete shop drawings indicating compliance with the Drawings, specifications, and other applicable Contract Documents, and that adequate and acceptable clearances will exist for entry, servicing, and maintenance. Acceptance of materials and equipment under this provision shall not be construed as authorizing deviations from the Specifications, unless the attention of the Owner's Representative and the Architect/Engineer has been directed in writing to the specific deviations. Data submitted shall not contain unrelated information unless pertinent information is properly identified.
- F. Replacement; Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, this material or equipment shall be replaced with the material or equipment originally specified at no additional cost to the Owner.

1.9 CONTRACTOR QUALIFICATIONS

- A. An acceptable Contractor for the work under this division must have personnel with experience, training and skill to provide a practical working system.
 - 1. The Contractor may be required to furnish acceptable evidence of having installed not less than three systems of size and type comparable to this project. The systems must have served satisfactorily for not less than 3 years. The superintendent must have had experience in installing not less than three such systems.
 - 2. The Contractor must have personnel with the proper licenses to perform electrical work under this Contract. In accordance with the Texas Electrical Safety and Licensing Act – Title 8, Occupation Code, Chapter 1305, Subchapter D, section 1305.151: “LICENSE REQUIRED. Except as provided by Section 1305.003, a person may not perform electrical work unless the person holds an appropriate license issued or recognized under this chapter.”
- B. The Contractor shall follow the safety procedures in addition to, and in accordance with, the requirements of the Project Safety Manual (PSM).
 - 1. The Contractor shall be responsible for training personnel under their employ in areas concerning safe work habits and construction safety. The Contractor shall continually inform personnel on hazards particular to this project and update the information as the project progresses.
 - 2. The Contractor shall secure electrical rooms, to limit access, prior to energizing high voltage (1000V or higher) equipment, and shall control access during the project after energization. The Contractor shall post and maintain warning and caution signage in areas where work is ongoing near energized equipment. The Contractor shall cover energized live parts when work is not being done in the equipment. This includes lunch and breaks.
 - 3. The Contractor shall strictly enforce OSHA lockout/tagout procedures. Initial infractions shall result in a warning. A second infraction shall result in the removal of the workman and his foreman from the site. Continued infractions shall result in removal of the Contractor from the site.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS

- A. Condition. Provide new products of manufacturers regularly engaged in production of such equipment. Provide the manufacturer's latest standard design for the type of product specified.
- B. NEC and UL.
 - 1. Products must conform to requirements of the National Electrical Code. Where Underwriters' Laboratories have set standards, listed products and issued labels, products used must be listed and labeled by UL.
 - 2. Materials and equipment shall be labeled and/or listed as acceptable to the authority having jurisdiction as suitable for the use intended. Where no specifications or specific model numbers are given, provide materials of a standard industrial quality.
- C. Space Limitations: Equipment selected must conform to the building features and must be coordinated with them. Electrical installation shall comply with the requirements of Article 110.26 and Article 110.34 of the National Electric Code (NEC) for working space, access, and dedicated equipment space. Do not provide equipment that will not suit arrangement and space limitations. Scaled drawings (1/4" = 1'-0") of electrical and telecommunication rooms shall be submitted for review by the Architect/Engineer and the Owner's Representative prior to installing equipment. See paragraph 1.07E above.

- D. Factory Finish. Equipment shall be delivered with a hard surface, factory-applied finish so that no additional field painting is required except for touch-up as required.
- E. Physical Size of Equipment: Equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless the Contractor demonstrates by product data, shop drawings, and coordination drawings that ample space exists for proper installation, operation, and maintenance.
- F. Enclosure: Provide NEMA 1 enclosure for indoor installation and NEMA 3R for outdoor enclosure, unless noted or specified otherwise. The enclosure shall be suitable for the environment per NEC, NEMA and ANSI standards.
- G. Conductors in Conduit: Conductors shall be installed in conduit. Exceptions are listed in individual Sections of the Division 26 and Division 28 specifications.

2.2 MANUFACTURER

- A. Where two or more units of the same class of material are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer, except as specifically noted in individual Sections of the specifications.

2.3 SUBSTITUTIONS

- A. Refer to Division 01 section on Material and Equipment, and to paragraph 1.08 of this Section.

2.4 NAMEPLATES AND DEVICE MARKING

- A. Refer to Section 26 05 53, Identification For Electrical Systems.

2.5 AUTOMATED EQUIPMENT AND CONTROLS

- A. Equipment and control systems where applicable, shall match, integrate, communicate and cooperate with new and existing systems, such as building automation, energy management, direct digital controls (DDC), fire detection and alarm, circuit breakers, transformers, etc.

PART 3 - EXECUTION

3.1 GENERAL

- A. Manufacturer's Recommendations: The manufacturer's published directions shall be followed in the delivery, storage, protection, installation, wiring, and connection of equipment and material. Promptly notify the Architect/Engineer and the Owner's Representative in writing of conflicts between the requirements of the Drawings and specifications and the manufacturer's directions, in accordance with paragraphs 1.05B and 1.06C of this Section. Obtain instructions from the Owner's Representative before proceeding with the work. Should the Contractor

perform work that does not comply with the manufacturer's directions or such instructions from the Owner's Representative, he shall bear costs arising in connection with the deficiencies.

- B. Site Observation: Site observation by the Architect/Engineer is for the express purpose of verifying compliance by the Contractor with the Drawings, specifications, and other applicable Contract Documents. Site observation by the Architect/Engineer shall not be construed as construction supervision, or indication of approval of the manner or location in which the work is being performed, or as being a safe practice or place. Site observation by the Architect/Engineer shall not be construed as inspection by the Authority Having Jurisdiction (AHJ) or other applicable code enforcement authority.
- C. Installation: Where product data or shop drawings are required, do not install equipment or materials until submittals are accepted by the Architect/Engineer and by the Owner's Representative. Use only equipment and materials accepted by the Architect/Engineer and the Owner's Representative. Equipment and materials installed prior to acceptance by the Architect/Engineer and Owner's Representative shall be removed at no additional cost to Owner and replaced at the Contractor's expense.
- D. Supervision:
 - 1. The Contractor of the work under this Division shall keep a competent superintendent or foreman on the job throughout the period of construction. Refer to Division One requirements and the Uniform General Conditions for additional information concerning supervision.
 - 2. It shall be the responsibility of such superintendent to study the Drawings, specifications, and other applicable Contract Documents, and familiarize himself with the work. He shall coordinate his work with other trades before material is fabricated or installed, and ensure that his work will not cause interference with another trade. Where interferences are encountered, they shall be resolved at the job site by the Contractor. Where interferences cannot be resolved without major changes to the Drawings, the matter shall be referred to the Architect/Engineer and the Owner's Representative for resolution in accordance with paragraphs 1.05B and 1.06C of this Section.

3.2 PROTECTION OF EQUIPMENT AND MATERIALS

- A. General:
 - 1. The Contractor shall follow the manufacturer's directions completely in the delivery, storage and handling of equipment and materials.
 - 2. Equipment and materials shall be tightly covered and protected against dirt, water, chemical, physical or weather damage and theft. At the completion of the work, fixtures, equipment and materials shall be cleaned and polished thoroughly and shall be returned to "as new" condition.
 - 3. Electrical cable, wire, and conductors shall be stored to prevent moisture and mechanical damage.
- B. Moisture. During construction, protect switchboard, transformers, motors, control equipment, and other items from insulation moisture absorption and metallic component corrosion by appropriate use of strip heaters, lamps or other suitable means. Apply protection immediately on receiving the products and maintain continually.
- C. Clean. Keep products clean by elevating above ground or floor and by using suitable coverings.

- D. Damage. Take such precautions as are necessary to protect apparatus and materials from damage. Failure to protect materials is sufficient cause for rejection of the apparatus or material in question.
- E. Finish. Protect factory finish from damage during construction operations and until acceptance of the project. Satisfactorily restore finishes that become stained or damaged.
- F. Weather. Protect equipment and materials from weather and sunlight by use of suitable coverings and storage indoors, or in suitable weather-protected containers. Materials and equipment marked by their manufacturer as suitable for storage outdoors may be stored according to manufacturer's markings. Maintain factory-installed coverings and wrappings until material is to be installed.

3.3 PREPARATION

- A. Coordination Drawings: The Contractor shall prepare one complete set of composite drawings. The intent of this process is to define areas of potential conflict and resolve those conflicts prior to fabrication or installation of work. In areas of congestion (where simply overlaying and drafting will create an unreadable product), the plan view scale shall be increased and multiple layered views shall be developed. Elevations of the individual elements shall be established, and elevations shall be drawn to illustrate that the ductwork, piping, raceway, and other systems and components will co-exist within the available space, and that the proper access to equipment, luminaires, valves, filters, etc. has been established for operation, service, removal and replacement. In addition to the above, the Contractor shall also prepare the following:
 - 1. Electrical/Mechanical Rooms. Prepare 1/4-inch scale coordination drawings of electrical rooms indicating location of equipment. Indicate the exact location of each component in relation to other mechanical, electrical, and plumbing (MEP) components within each room. Include location(s) and quantity of raceway(s) and sleeve(s) stubbed up through floor slab for power, lighting, control, grounding, communications, and low-voltage system(s). These coordination drawings shall take into account the configuration of the mechanical, electrical, and telecommunications equipment which has been proposed for use in the project, particularly where it differs in configuration from the equipment shown on the Drawings.
 - 2. Review: The completed "Composite Drawings" shall be prepared prior to installation. Work that proceeds without appropriate coordination will be subject to removal and relocation at no additional cost to the Owner.
- B. Test Procedures:
 - 1. Furnish documentation from equipment manufacturer for the startup and field testing procedures for equipment installed as a part of this project.
 - 2. Startup and testing procedures shall include prerequisite conditions, system and equipment alignments and lineups, sequential steps for execution of the test, shutdown procedures, and criteria for satisfactory test completion and test failure.
 - 3. Startup and testing procedures shall address and demonstrate modes of system or equipment operation, including startup, manual, unattended/automatic, and shutdown procedures, as well as procedures for testing and demonstration of abnormal or emergency operating conditions.
 - 4. Include forms and logs to be used during field testing. Forms and logs shall include the range of permissible values for monitored parameters, as applicable.

3.4 SAFETY

- A. Implement the following safety procedures in addition to, and in accordance with, the requirements of Division One and the Uniform General Conditions:

1. The Contractor shall be responsible for training personnel under their employ in areas concerning safe work habits and construction safety. The Contractor shall continually inform personnel of hazards particular to this project and update the information as the project progresses.
2. Prior to energizing panelboards within the scope of work, secure affected electrical rooms to limit access to line voltage. Line voltage shall be defined as above 50 volts, for the purpose of controlling access. During and after energization of panelboards, control access to electrical rooms for the duration of the project. Post and maintain warning and caution signage in areas where work is on-going near energized equipment. Cover energized live parts when work is not being done in the equipment. This includes lunch and breaks.
3. Strictly enforce OSHA lockout/tagout procedures. Initial infractions shall result in a warning. A second infraction shall result in the removal of the workman and his foreman from the site. Continued infractions shall result in removal of the Contractor from the site.

3.5 INSPECTION

- A. Examination. Examine the areas and conditions under which equipment and systems are to be installed, and notify the Owner's Representative in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- B. Coordination. Carefully investigate structural and finish conditions and coordinate the work in order to avoid interference between the various phases of work. Work shall be organized and laid out so that it will be concealed in furred chases, suspended ceilings, and similar elements in finished portions of the building, unless specifically noted to be exposed. Work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.

3.6 INSTALLATION

- A. Cooperation with Other Trades. Cooperation with trades of adjacent, related or affected materials or operations, and of trades performing continuations of this work under subsequent contracts, is considered a part of this work in order to effect timely and accurate placing of work and to bring together, in proper and correct sequence, the work of such trades. Provide other trades, as required, templates, patterns, setting plans and shop details for the proper installation of the work and for purposes of coordinating adjacent work. Electrical power connections for mechanical and plumbing equipment are in this Division unless noted otherwise. Verify electrical characteristics of equipment with other Divisions before roughing in the electrical connections.
- B. Workmanship. Work shall be performed by workmen skilled in their trade. The installation shall be complete and installed in a neat and workmanlike manner in accordance with NEC 110.12 and FPM accompanying, and as described in ANSI/NECA 1-2000 "Standard Practices for Good Workmanship in Electrical Contracting", and other ANSI approved installation standards.
- C. Concrete Equipment Pads.
 1. Refer to structural Drawings and specifications for design criteria.
 2. Where not otherwise indicated, install 2 inch thick reinforced concrete foundation pads for indoor floor-mounted equipment, except where direct floor mounting is required such as at the metal platform. For equipment mounted outdoors, provide concrete foundations a minimum of 6 inches above grade. Provide reinforcing steel as recommended by the structural engineer and as detailed on the Drawings. Pour pads on roughened floor slabs, sized so that outer edges extend a minimum of 3

- inches beyond equipment. Trowel pads smooth and chamfer edges to a 1-inch bevel. Secure equipment to pads as recommended by the manufacturer.
3. Anchor Bolts. Furnish and install galvanized anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts shall be of the size and number recommended by the manufacturer of the equipment and shall be located by means of suitable templates. When equipment is placed on vibration isolators, the equipment shall be secured to the isolator and the isolator secured to the floor, pad, or support as recommended by the vibration isolation manufacturer.
- D. Setting of Equipment. Provide permanent and temporary shoring, anchoring, and bracing required to make parts stable and rigid; even when such shoring, anchoring, and bracing are not explicitly called for.
1. Equipment must be leveled and set plumb.
 2. Sheet metal enclosures mounted against a wall shall be separated from the wall not less than 1/4 inch by means of corrosion-resistant spacers, or by 3 inches of air for freestanding units. Use corrosion-resistant bolts, nuts and washers to anchor equipment.
 3. In sufficient time to be coordinated with work under other divisions, provide shop drawings and layout work showing exact size and location of sleeves, openings or inserts for electrical equipment in slabs, walls, partitions and chases.
 4. Provide adequate support for freestanding panels, switchboards, enclosures, and other equipment. This shall include bolting to the floor, concrete equipment pad, or solid structural steel to prevent tipping. Install free-standing electrical equipment on concrete equipment pads in accordance with paragraph 3.05C, this Section, except where equipment is noted and designed for mounting directly on the concrete floor slab. Under no condition shall equipment be fastened to non-rigid building steel such as removable platform steel gratings, handrails, etc.
 5. Provide racks and supports, independently mounted at structure, to support electrical equipment and systems supplied and installed under this contract. Do not mount or suspend equipment from supports provided for equipment and systems by other Divisions, except where specifically noted or indicated on Drawings.
 6. Refer to Section 26 05 29, Metal Framing and supports, for additional requirements.
- E. Sealing of Equipment. Seal openings into equipment to prevent entrance of animals, birds and insects, as well as to prevent ingress of moisture, dust, dirt, and similar contaminants.
- F. Motors.
1. Motors are specified in Divisions 21, 22 and 23.
 2. Electrical work includes the electrical connection of motors, except those which are wired as a part of equipment.
 3. Refer to Division 23 and other applicable Divisions for wiring and connection of motors and equipment furnished by those Divisions.
 4. The Contractor shall note that the electrical Drawings are based on the equipment scheduled and indicated on the Drawings. Should mechanical equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.
 5. Provide interconnecting wiring for the installation of the power required. Provide disconnect switches as required for proper operation, as indicated on the Drawings or required by applicable code. Combination starters, individual starters, and other motor starting apparatus, not specifically scheduled or specified as provided by the equipment manufacturer under the scope of other Divisions shall be provided under the scope of Division 26.
 6. Other Divisions will provide complete wiring diagrams indicating power wiring and interlock wiring. Diagrams shall be submitted to the Architect/Engineer for review. Diagrams will be based on accepted equipment and be complete full phase and

interlock control drawings, not a series of manufacturer's individual diagrams. They will be followed in detail. For additional clarification, refer to Division 23, Controls.

- G. Concealed Work. Conceal electrical work in walls, floors, chases, under floors, underground and above ceilings except:
1. Where shown or specified to be exposed. Exposed is understood to mean open to view.
 2. Where exposure is necessary to the proper function.
 3. Where size of materials and equipment preclude concealment. Obtain the written consent of the Owner's Representative and the Architect/Engineer to leave materials exposed in finished spaces of the building.
- H. Application. Unless otherwise indicated, power will be utilized as follows:
1. 480 volts, three phase: motors 3/4 horsepower and larger.
 2. 120 volts, single phase: motors 1/2 horsepower and smaller.
 3. 277 volts, single phase: fan powered boxes.
 4. 120 volts, single phase: incandescent lighting.
 5. 277 volts, single phase: fluorescent and high-intensity-discharge lighting.
 6. 120 volts, single phase: convenience outlets, dedicated equipment, lab-track terminal boxes without fans.
 7. 208 volts, single and three phase: specialty outlets.
 8. 480 volts, three phase: special power and equipment; verify for each unit of equipment.
- I. Transformers. Use transformers to change the service to the required utilization voltages. J. Connections to Equipment - Other than Division 26. For equipment furnished under other Divisions, and for equipment furnished by the Owner, provide final electrical connections to such items of equipment. Obtain detailed shop drawings of equipment from the applicable Division or supplier indicating the exact number and location of rough-in points. Such final shop drawings may indicate adjustments in total number and exact location of rough-in points, and in equipment dimensions. Making adjustments to field conditions is considered a part of the work required.
1. Roughing-in: When roughing-in, provide electrical branch circuits to various items of equipment. Terminate at proper points as indicated on detailed equipment shop drawings, or as directed. Use Drawings accompanying these specifications only for general routing of circuiting. Do not use Drawings accompanying these specifications for rough-in locations.
 2. Final Connections: Millwork, casework, and similar equipment will include service fittings such as switches, duplex receptacles, data/communications outlets, and luminaires on the casework or equipment. Provide branch circuit connection to match electrical connection requirements of service fittings.
- K. Accessories. Offsets, fittings, expansion joints, anchors and accessories that are required for a complete system shall be provided, even if not specifically indicated on the Drawings or mentioned in the specifications. Offsets, transitions and changes in direction of conduit, cable trays, raceways and busways shall be made to maintain proper headroom. Provide pullboxes, fittings, etc., required as a result of these transitions and changes in direction.
- L. Observation prior to cover-up or seal-in of walls and ceilings. Perform the following in accordance with the applicable requirements of Division One and the General Conditions:
1. Prior to the installation of ceiling material, gypsum, plaster, or acoustical board, the Contractor shall notify the Owner's Representative so that arrangement can be made for observation or inspection of the above-ceiling area about to be "sealed" off. The Contractor shall provide advance notice in accordance with the applicable

- requirements of Division One and the General Conditions. Where not specified, required, or directed elsewhere, provide not less than 10 working days' advance notice.
2. Above-ceiling areas will be subject to a formal inspection before ceiling panels are installed, or installation is otherwise concealed from view. Electrical work at and above the ceiling, including items supported by the ceiling grid, shall be complete and installed in accordance with contract requirements, including power to luminaires, fans, and other powered items. The purpose of this inspection is to verify the completeness and quality of the installation of the electrical systems and other above ceiling special systems such as cable tray systems. The ceiling supports shall be in place so that access panel and luminaire locations are identifiable, and so that clearances and access provisions may be evaluated.
 3. No ceiling materials may be installed until the resulting deficiency list from this inspection is completed and approved by the Owner's Representative.
- M. Finish. Coordinate with Division 9 to paint exposed conduit to match adjacent walls, unless otherwise directed.

3.7 EXISTING FACILITIES

- A. Responsibility. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing or replacing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and maintenance of electrical services for new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing such temporary protection upon completion of the work.
- B. Services. The Contractor shall provide temporary or new services to existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.
- C. Access. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, luminaries, air conditioning ductwork and equipment, etc., to provide this access, and shall reinstall same upon completion of work in the areas affected.
- D. Existing Devices. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed, remove and reinstall in locations approved by the Architect/Engineer devices required for the operation of the various systems installed in the existing construction. This is to include, but is not limited to, temperature controls, system devices, electrical switches, relays, luminaires, fixtures, piping, conduit, etc.
- E. Outages. Outages of services as required by the new installation will be permitted, but only at a time approved by the Owner. The Contractor shall coordinate with the Owner's Representative to arrange for service outages. The Contractor shall allow the Owner sufficient time to schedule for required outages, in accordance with the applicable requirements of Division One and the General Conditions. Where not specified, required or directed elsewhere, allow a minimum of 21 working days for the Owner to schedule for required outages. The time allowed for outages will not be during normal working hours or during hours of research and instruction, unless otherwise approved by the Owner's Representative. Costs of outages, including overtime charges, shall be included in the contract amount.
- F. Adjacent Facilities. Coordinate work among the various trades to minimize disruption to existing processes, procedures, and equipment in spaces adjacent to areas of demolition and

renovation work. Coordinate with Owner's Representative to schedule work producing noise or structure-born vibrations, including but not limited to cutting, drilling, coring, and use of impact tools.

3.8 EQUIPMENT AND DEVICE MARKING

- A. Designations. Identify equipment, devices, feeders, branch circuits and similar items with the same designations as indicated on the Drawings.
- B. Nameplates. Externally mark electrical equipment with nameplates identifying each and the equipment served. Supply blank nameplates for spare units and spaces.
- C. Refer to Section 26 05 53 for additional requirements.

3.9 SLEEVES, PENETRATION, CUTTING AND PATCHING

- A. General. Cut and patch walls, floors, etc., resulting from work in existing construction. Provide for the timely placing of sleeves for raceway and exposed cabling passing through walls, partitions, beams, floors and roof while same are under construction. If openings, sleeves, and recesses are not properly installed and cutting and patching become necessary, it shall be done at no expense to the Owner. Secure permission from the Owner's Representative before cutting or patching a constructed or existing wall. Where roofs or walls are fire rated, penetrations shall be completely sealed using UL-listed materials and procedures sufficient to preserve the fire rating. Comply with special requirements of local authorities.
- B. Structure. Do not cut or core through structural beams, joists, load-bearing walls, grade beams, or similar load-bearing structure. Where limited space is available above the ceilings below concrete beams or other deep projections, notify the Owner's Representative in writing, including a proposed solution, and request a resolution. Approval shall be obtained from the Owner's Representative and the Architect/Engineer for each penetration.
- C. Penetrations.
 - 1. This contract requires core drilling of floor or wall penetrations as indicated on Drawings. Core drilling shall be in accordance with structural specifications. Floor penetrations shall include a sleeve that extends above the floor 2 inches, except where plugs and caps are specified or indicated flush with floor or foundation pad. Electrical penetrations shall be coordinated with structure during design, and shall be made in compliance with structural requirements specified in the structural Drawings and specifications. Field modifications are required to be reviewed and approved by structural engineer prior to installation.
 - 2. Penetrations shall be sealed in accordance with the requirements of Division 7, Firestopping. Coordinate with Division 7 to provide firestopping systems and materials that are compatible with the penetrations for systems and equipment furnished and installed under Division 26.
 - 3. Provide sleeves for conduit penetrations of smoke, fire, and sound rated partitions. Install sleeve with a minimum of 1 inch diameter where penetrating the exterior drywall.
 - 4. Provide proper sizing of sleeves or core-drilled holes to accommodate their through-penetrating items. In general, provide conduit sleeves two standard sizes larger than their through-penetrating items. Provide larger sleeves as required to allow passage of couplings for through-penetrating items.
- D. Sealing and Firestopping.

1. Voids between sleeves or core-drilled holes and pipe passing through fire-rated assemblies shall be firestopped to meet the requirements of ASTM E 814, in accordance with Division 7 requirements for Firestopping.
 2. Where the routing of cable tray passes through fire-rated walls, floors or other fire-rated boundaries, coordinate with Division 7 to provide removable firestopping system.
 3. Furnish and install UL Systems Classified, intumescent material capable of expanding up to 8 to 10 times when exposed to temperatures beginning at 250° F, for the sealing of holes or voids created to extend electrical systems through fire rated floors and walls, in order to prevent the spread of smoke, fire, toxic gas or water.
 4. Fire barrier products shall be used to create through-penetration firestop systems as required. Firestop systems shall be listed in the Underwriter's Laboratories Building Materials Discovery, Through Penetration Firestop Systems (XHEZ).
 5. Install firestop materials and systems according to their UL Systems Classifications, manufacturer instructions, manufacturer recommendations, and the requirements of applicable Division 7 specifications.
- E. Conduit Sleeves. Conduit sleeve shall be two standard sizes larger than the size of conduit it serves, except where "Link Seal" casing seals are used in sleeves through walls below grade. Sleeves in floor shall extend a minimum of two inches above the finished floor. Conduit passing through concrete masonry walls above grade shall have 18-gauge galvanized steel sleeves. Sleeves set in concrete floor construction shall be at least 16-gauge galvanized steel except at conduit supports. Sleeves set in concrete floor construction supporting conduit risers shall be standard weight galvanized steel. Sleeves supporting conduit risers 3 inches and larger shall have three 6 inch long reinforcing rods welded at 120 degree spacing to the sleeve, and shall be installed embedded in the concrete or grouted to existing concrete. Where the conduit passes through a sleeve, no point of the conduit shall touch the sleeve. Seal around penetrations through sleeving as indicated under firestopping as specified herein, and in compliance with the requirements of Division 7 specifications.
- F. Penetrations Below Grade. Sleeves penetrating walls below grade shall be standard weight black steel pipe with 1/4-inch thick steel plate secured to the pipe with continuous fillet weld. The plate shall be located in the middle of the wall and shall be two inches wider in radius than the sleeve it encircles. The entire assembly shall be hot-dipped galvanized after fabrication. Seal off annular opening between conduit and sleeve with "Link Seal" casing seal as manufactured by Thunderline Corporation of Wayne, Michigan. Size conduit sleeve to accommodate the casing seal. Use Series 300 casing seals for pipe 3/4-inch through 4-inch and Series 400 casing seals for pipe sized 5-inch and larger.
- G. Methods of Cutting: Openings cut through concrete and masonry shall be made with masonry saws and core drills, and at such locations acceptable to the Owner's Representative. Impact type equipment shall not be used except where specifically accepted by the Owner's Representative. Openings in precast concrete slabs for conduits, outlet boxes, etc., shall be core drilled to exact size.
- H. Restoration. Restore openings to "as new" condition under the appropriate specification Section for the materials involved, and match remaining surrounding materials and/or finishes.
- I. Masonry. Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Provide adequate supports during the cutting operation to prevent damage to the masonry caused by the cutting operation. Structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Owner's Representative.
- J. Structure. No cutting, boring, or excavating which will weaken the structure shall be undertaken. Coordinate with structure for placement of conduit, sleeves, and the like through

beams, joists, slabs, mats, and other structural components and systems prior to forming of those structural components and systems.

- K. Watertight. Where sleeves pass through roof or floors requiring waterproof membrane, lead flashing with a density of at least three pounds per square foot shall be built into the membrane a minimum of six inches to provide a watertight installation. Provide other watertight installation materials as detailed on the Drawings and as specified under Division 7 – Roofing.
- L. Escutcheons. Provide heavy chrome-plated or nickel-plated plates on conduit passing through walls and ceilings in finished areas. Escutcheons shall be B&C No. 10, or accepted substitution, chrome-plated steel plates with concealed hinges.
- M. Roof Penetrations and Flashings. Furnish and install pipe, conduit and duct sleeves, and flashing compatible with the roofing installation for roof penetrations. Coordinate with Division 7.

3.10 CLEANING, ADJUSTING AND START-UP

- A. Cleaning. Clean electrical equipment, components, and devices prior to installation of final finish or covers, prior to startup and testing, prior to final observation by Architect/Engineer and Owner's Representative, and as required under individual Sections of the Division 26 specifications.
- B. Adjusting. Adjust equipment, devices, and systems as specified under individual Sections of these Specifications and in accordance with manufacturer's instructions for proper functioning during modes of operation, including emergency and shutdown conditions.
- C. Factory Authorized Representative. Where specified for an individual item of electrical equipment, provide a factory authorized representative for adjustment, start-up, and testing of equipment, and instruction of Owner's operating personnel. Certify that these services have been performed by including a properly executed invoice for these services or a letter from the manufacturer.

3.11 TESTING

- A. Test Conditions. Use field startup and testing procedures submitted in accordance with paragraph 1.07H of this Section and accepted by the Owner's Representative and the Architect/Engineer. Place circuits and equipment into service under normal conditions, collectively and separately, as necessary to determine satisfactory operation. Perform specified tests in the presence of the Owner's Representative. Furnish instruments, wiring, equipment and personnel required for conducting tests. Demonstrate that the equipment operates in accordance with requirements of the Drawings and specifications. Special tests on certain items, when required, are specified in the individual specification Sections. Where testing is specified or otherwise required to be performed by an independent testing company, use an Owner-approved NETA-certified testing company.
- B. Test Conditions. Use field startup and testing procedures prepared in accordance with paragraph 3.03B of this Section. Place circuits and equipment into service under normal conditions, collectively and separately, as necessary to determine satisfactory operation. Perform specified tests in the presence of the Owner's Representative. Furnish instruments, wiring, equipment and personnel required for conducting tests. Demonstrate that the equipment operates in accordance with requirements of the Drawings and specifications. Special tests on certain items, when required, are specified in the individual specification

Sections. Where testing is specified or otherwise required to be performed by an independent testing company, use an Owner-approved NETA-certified testing company.

- C. Test Dates. Schedule final acceptance tests sufficiently in advance of the contract completion date to permit adjustment and alterations within the number of days allotted for completion of the contract. Inform the Owner's Representative in advance of test dates in accordance with the applicable requirements of Division One and the General Conditions. Where not specified, required, or directed otherwise, allow a minimum of at least 10 working days advance notice.
- D. Retests. Conduct retests as directed by the Owner's Representative of such time duration as may be necessary to assure proper functioning of adjusted or altered parts or items of equipment. Delays resulting from retests do not relieve the Contractor of his responsibility under this contract.
- E. Commissioning. Coordinate with commissioning agent, as applicable, for field testing and commissioning of electrical components and systems.
- F. Test Reports. Submit copies of test reports to the Architect/Engineer in accordance with Division One requirements.

3.12 OPERATING AND MAINTENANCE MANUALS

- A. General. The Contractor shall provide, in loose-leaf binders, complete operating and maintenance data of each manufactured item of equipment used in the electrical work at least four weeks before Architect/Engineer's final review and observation of the project. Descriptive data and printed installation, operating and maintenance instructions for each item of equipment will be included. A complete double index will be provided as follows.
- B. Format and content. The Operating and Maintenance Manual will be submitted in quantities and format as specified under Division One for Submittals. Provide quadruplicate where quantity is not specified. Operating and Maintenance Manual shall include:
 - 1. Descriptive data of each system and piece of equipment, including ratings, capacity, performance data, operating curves and characteristics, and wiring diagrams.
 - 2. Full detailed spare parts list, including source of supply for each piece of equipment.
 - 3. Printed instructions describing installation, operation, service, maintenance, and repair of each piece of equipment.
 - 4. Typewritten test reports of tests made of materials, equipment and systems under this Division. Test reports will include the dates of the tests, name of person conducting and witnessing the tests, and record of conditions relative to the tests.
 - 5. Copies of "Reviewed" shop drawings and submittals.
 - 6. Print copies of the record Drawings. Refer to paragraph 1.07I of this Section.

END OF SECTION

SECTION 26 05 19

INSULATED CONDUCTORS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of insulated conductors.

1.2 REFERENCE STANDARDS

- A. AEIC No. 6 - Specifications for Ethylene-Propylene-Rubber-Insulated Power Cables 5,000 to 35,000 Volts.
- B. ANSI/IEEE 386 - Separable Insulated Connectors for Power Distribution Systems Above 600 Volts.
- C. ANSI/UL 83 - Thermoplastic-Insulated Wires and Cables.
- D. ANSI/UL 1072 - Medium-Voltage Power Cables.
- E. IEEE No. 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations.
- F. ICEA S-61-402 (NEMA WC 5) - Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- G. ICEA S-68-516 (NEMA WC 8) - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- H. ANSI/UL 2196 "Tests for Fire Resistive Cables"
- I. CSA C22.2 #124
- J. UL Fire Resistance Directory

1.3 SUBMITTALS

- A. Provide product data on the following:
 - 1. 600-volt conductor, splicing and terminating materials.
 - 2. 5 kV insulated conductor, splicing and terminating materials.
- B. Provide cable high voltage factory test reports.

PART 2 – PRODUCTS

2.1 IDENTIFICATION

- A. Provide new insulated conductors marked according to NEC Article 310.

2.2 600-VOLT INSULATED CONDUCTORS

- A. Size. As shown on the drawings.
- B. Construction.
 - 1. Conductor. Soft-drawn, annealed copper. Solid for #12 and #10 and Stranded for all other sizes.
 - 2. Insulation. Unless otherwise noted on the drawings, use THHN/THWN-2 for general wiring. Use XHHW-XHHW-2 for conductors installed below grade.
- C. Use. For general wiring use No. 12 minimum. For field-installed control wiring use No. 14 or larger stranded conductors.
- D. Listing. Single Conductor. UL 83.

2.3 5,000-VOLT INSULATED CONDUCTORS (133% INSULATION)

- A. Size. As shown on the drawings.
- B. Single Conductor Construction.
 - 1. Single uncoated annealed copper conductor with Class B stranding.
 - 2. Extruded semi-conducting thermosetting conductor screen firmly bonded to the overlaying insulation.
 - 3. Ethylene-propylene-rubber (EPR) insulation 115 mils thick.
 - 4. Extruded semi-conducting thermosetting insulation screen.
 - 5. Copper shielding tape 5 mils thick helically applied with a minimum 12.5 percent overlap or 6 corrugated drain wires embedded in jacket.
 - 6. Polyvinyl chloride jacket 80 mils thick.
- C. High Voltage Factory Test.
 - 1. Corona level test with a maximum partial discharge of 5 picocoulombs.
 - 2. AC test: 13 kV for 5 minutes.
 - 3. DC test: 35 kV for 15 minutes.
 - 4. Insulation resistance test: IR constant to be 50,000 megohms per 1000 feet minimum.
 - 5. Use test procedures given in ICEA S-68-516 and AEIC No. 6.
 - 6. Certified test reports with test data and corona level plots are to be submitted for review prior to shipment.
 - 7. Engineer may witness test.
- D. Type. Single Conductor. MV-105.
- E. Listing. UL 1072.
- F. Acceptable Manufacturers. Okonite, Southwire, Kerite.

2.4 HIGH VOLTAGE TERMINATIONS

- A. Terminations.
 - 1. Terminations - Medium voltage terminations shall be equal to 3M 5630K series, Class 1, 5-35 kV, cold-shrink rubber termination kits.
- B. Compatibility. Terminating materials must be compatible with the cable supplied. Submit proof of the acceptability by the cable manufacturer of any splicing or terminating materials.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Protection. Unless otherwise indicated, mechanically protect conductors for systems by installing in raceways. Do not install the conductors until raceway system is complete and properly cleaned. Use Polywater J cable lubricant when pulling conductors. Do not bend any conductor either permanently or temporarily during installation to radii less than four times the outer diameter of 600-volt insulated conductors, or less than twelve times the outer diameter of the completed 15 kV cable. Do not exceed manufacturer's recommended values for maximum pulling tension.
- B. Splices and Terminations. Use pressure-type lugs or connectors for terminations or splices of all stranded conductors. Use ring-tongue type terminators on all control wiring. Below grade terminations shall be waterproof.
- C. Appearance. Neatly and securely bundle or cable all conductors in an enclosure using nylon straps with a locking hub or head on one end and a taper on the other.

3.2 600-VOLT INSULATED CONDUCTORS

- A. Size. Install conductor sizes as indicated.
- B. Home Runs. Provide branch circuit homeruns as indicated on plans. Homerun designations are indicated on Sheet E-001. Provide the number of homeruns as indicated on plans. A maximum of 6 phase conductors may be installed in one conduit. Include a separate neutral conductor with each phase conductor for all 120V circuits. Common neutrals are not permitted. For 277V lighting circuits one neutral conductor may be used for three phase conductors. Use home run circuit numbers as indicated for panelboard connections. For isolated ground circuits provide an additional ground conductor as indicated on the panel schedules. Provide No. 10 AWG conductor for the entire circuit length for single-phase, 20 ampere circuits for which the distance from panelboard to the last outlet is more than 100 feet for 120 volt circuits and 200 feet for 277 volt circuits.
- C. Color Code. Use factory-colored insulated conductors for No. 10 and smaller conductors and color code larger insulated conductors with an approved field-applied tape. Use different colors for control wiring. Follow the color scheme below.

<u>Line</u>	<u>208/120</u>	<u>480/277</u>
A or L1	Black	Brown
B or L2	Red	Purple
C or L3	Blue	Yellow
Neutral	White	Gray

<u>Line</u>	<u>208/120</u>	<u>480/277</u>
A or L1	Black	Brown
Ground	Green	Green
Switch Leg	Pink	Pink

Where more than one conductor of the same phase or more than one neutral conductor occur at the same outlet or junction box, these conductors shall be identifiable from each other by use of stripes or distinguishing markings. All wiring associated with isolated ground receptacles (line, neutral, ground) shall have a yellow tracer on each conductor.

- D. Field Testing. Insulation resistance of all conductors shall be tested. Each conductor shall have its insulation resistance tested after the installation is completed and all splices, taps and connections are made except connection to or into its source and point (or points) of termination. Insulation resistance of conductors which are to operate at 600 volts or less shall be tested by using a Biddle Megger of not less than 1000 volts d-c. Insulation resistance of conductors rated at 600 volts shall be free of shorts and grounds and have a minimum resistance phase-to-phase and phase-to-ground of at least 10 megohms. Conductors that do not exceed insulation resistance values listed above shall be removed at Contractor's expense and replaced and test repeated. The Contractor shall furnish all instruments and personnel required for tests, shall tabulate readings observed, and shall forward copies of the test readings to the Owner in accordance with Section 26 05 00. These test reports shall identify each conductor tested, date and time of test and weather conditions. Each test shall be signed by the party making the test.

3.3 5 KV INSULATED CONDUCTORS

- A. Bonding. At each termination, bond tape shield to grounding conductor.
- B. Terminations. Provide terminations as specifically indicated. Have terminations installed by an experienced cable terminator in strict accordance with the termination manufacturer's instructions and the cable manufacturer's recommendations. Submit cable terminator's qualifications for Owner's approval.
- C. Fireproofing. Fireproof each individual high voltage insulated conductor for entire length exposed in existing manhole PMH 22D. Use Scotch 77 tape with Scotch 69 glass cloth overlay wrapped in the opposite direction. Provide a minimum 25 percent overlap of each tape layer.
- D. Installation. Wrap cables horizontally around manhole a minimum of one time before exiting. Cable racks for cable support are existing. Use plastic cable ties to secure cables to racks.
- E. Identification. Identify each circuit in manhole with a laminated plastic tag securely fastened to the conductors with tie wrap.
- F. Field Testing:
1. High potential proof tests shall be made on all high voltage cables before final inspection and acceptance of work. Thirty days before the installation of cables is complete and ready for testing, the Contractor shall notify the Owner for approval of the testing company. The Contractor shall cooperate with and give all necessary assistance to this agency while the tests are being conducted. In the event of a test failure, Contractor shall repair any defects in installation and re-test at no additional cost to Owner.

2. A non-destructive dc testing service, such as "Kenotron," Westinghouse "High Pot Tester," or approved substitution, capable of generating approximately 100,000 Vdc under normal leakage conditions of acceptable cable shall be used for the tests.
 3. All cables shall be tested in place with terminations made up but not connected to switchgear or any other load device or dead-end seal. Cables with dead-end seals shall be temporarily opened and resealed.
 4. In case of failure during the test, the Contractor shall locate the faulty component. The Owner shall be notified before repairs are made.
 5. Should the test reports indicate that the condition of the cable is unsatisfactory, in the opinion of the Owner, the Contractor shall make all repairs and/or replacements as necessary. Additional tests shall be made at the Contractor's expense, on all repaired sections using the same testing agency. Cable installations will not be accepted until satisfactory certified proof test reports are obtained.
 6. Adequate means shall be taken to ensure safety during the tests and all safety instructions of the test operator shall be carried out.
 7. Prior to each high potential test, each high voltage cable conductor shall be separately "megged" with a 2,500-volt mega-ohms meter, or equal, from conductor to sheath or ground. Low megger readings of less than 25 mega-ohms shall be cause for rejection of the cables.
- G. Each cable shall be tested for a minimum of 10 minutes or until the current reading levels off and remains steady for at least 3 minutes. The potential shall be raised at a slow uniform rate with current readings taken every 15 seconds until full test voltage is reached; thereafter, current readings shall be recorded separately. The removal of the voltage shall be done in a manner to prevent damaging the cable.
- H. The test voltage shall be in accordance with ICEA recommended values except where the cable terminates in a switch or switchgear with a lower recommended test value, in which case the lower value shall be used. Cables with one or more switching points in a cable run shall be sectionalized with the switches and tested in sections in order to test the cable at the highest possible voltage which the ICEA recommends.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section specifies the furnishing and installing of grounding and bonding equipment for electrical systems.

1.2 REFERENCE STANDARDS

- A. ANSI/IEEE Std 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- B. ANSI/NEMA GR 1-2007 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings.
- C. ANSI/TIA/EIA 607 - Commercial Building Grounding and Bonding Requirements for Telecommunications.
- D. ANSI/UL 467 - Grounding and Bonding Equipment.
- E. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System.
- F. IEEE 1100 - Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book).
- G. NFPA 70 - National Electrical Code (NEC).
- H. NFPA No. 780 - Lightning Protection Code.
- I. UL 96A - Master Labeled Lightning Protection System, Installation Requirements.

1.3 SUBMITTALS

- A. Product Data. Submit product data sheets, including complete descriptive information on materials and installation methods.
- B. Approvals: Secure formal approval of shop drawings and product data prior to ordering material. Secure approvals in sufficient time to allow installation of concealed system components without delaying the project.
- C. Testing: Submit documentation for field testing of completed grounding system, as required under paragraph 3.7B of this Section.
- D. Note to specifier: edit for Owner preferences on file format and media
- E. As-Built Record Drawings. The Contractor shall maintain a master set of As Built record drawings that shows changes and deviations from the Drawings, in accordance with

Division One requirements and Section 26 00 00. Deliver As-Built record drawings to Owner upon Owner acceptance of project. Where not specified otherwise in Division 1 or the General and Supplementary Conditions of the construction contract, deliver one set of As-Built record drawings plotted full-scale on mylar with permanent ink, prepared to 1/8-inch scale with 1/8-inch text. Also deliver one set of As-Built record drawings on CD-Rom or similar electronic media acceptable to the Owner. Drawing files shall be in AutoCAD (.dwg) and Adobe Acrobat (.pdf).

PART 2 - PRODUCTS

2.1 GROUND RODS

- A. None required

2.2 CONNECTIONS

- A. Materials. Unless otherwise noted, provide exothermic welded type grounding connections for bonds and connections made below grade, embedded in structure, or otherwise concealed. For above grade connections not embedded in structure or otherwise concealed, provide mechanical bolted-type connections utilizing high-conductive copper alloy or bronze lugs or clamps. Where required, provide plated connectors which will not cause electrolytic action between the conductor and the connector.

- B. Listing. UL 467.

2.3 CONDUCTORS

- A. Materials. Provide grounding conductors fabricated from annealed copper with conductivity ≥ 98 percent IACS conductivity.
 1. Use solid conductor for No. 12 and No. 10 AWG.
 2. Use stranded conductor for No. 8 AWG and larger.
 3. Use stranded conductor for applications subject to continuous vibration, such as engine generators and terminations at motors.
 4. Use stranded, tinned, annealed copper cable for #2 AWG or larger installed inside the building or structure.

- B. Insulation. Where insulated grounding conductors are specified or required, provide green-colored 600-volt rated insulation, type XHHW, THWN, or RHW. Insulation type shall be compatible with associated power and lighting system conductors.

- C. Location and Application.
 1. Inside building or structure. Provide insulated copper grounding conductors, except where bare copper grounding conductors are indicated on Drawings or specified in this or other Sections.
 2. Outside building or structure. Use bare copper grounding conductors, including below-grade building grounding ring (counterpoise).
 3. Bonding jumpers. Use bare copper conductor.

- D. Listing. UL 83.

2.4 GROUND BUS

- A. Where a field-provided ground bus-bar is required or indicated, provide bus-bar drilled and tapped with double-lug terminations for the quantity of ground connections indicated on the Drawings plus 25% spare capacity, wall-mounted on insulated supports. Use round-edge copper bar with ≥ 98 percent International Annealed Copper Standard (IACS) conductivity. Size the bus-bar for not less than 25 percent of the aggregated cross-sectional area of the related feeders. A minimum cross-sectional size of 1/4 inch by 2 inches is required; where ground bus-bar of larger dimensions is indicated on plans or specifications provide the bus-bar with the larger dimensions. See E 2.4B for chemical ground rod measurements in test well.

2.5 MANUFACTURER

- A. Copperweld.
- B. Cadweld.
- C. Burndy.
- D. Harger.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install grounding system in accordance with the requirements of the National Electrical Code (NEC), Article 250, and other applicable codes and standards. Coordinate installation of grounding and lightning protection system components with structural and civil work and placement of building structural mat.
- B. Install grounding conductors continuous, without splice or connection, between equipment and grounding electrodes. Connection to ground busbars is permitted as an exception to the restriction against splices in grounding conductors. Grounding conductors shall be as short and straight as possible, and protected from mechanical damage.
- C. Connect grounding electrode conductors to metal water pipe using suitable ground clamp, where metal water pipe is available and accessible and not protected by an insulating anti-corrosion covering. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter. The grounding electrode conductor shall not be spliced
- D. Install fusion welded (exothermic) grounding connectors where they are below grade, concealed, or inaccessible. Above grade at accessible locations, use copper or bronze lugs and clamps. Grounding and lightning protection system connections made in conjunction with placement of the building structural mat shall be exothermic ground connectors.
- E. Strap grounding clamps shall not be used. Connections requiring bolting shall be made up with Monel metal bolts, washers and nuts. Connections shall be made only after surfaces have been cleaned, or ground to expose virgin metal.
- F. Where grounding conductors are installed in metallic raceway, bond to each end of metallic raceway where grounding conductors enter or exit the metallic raceway system. Metallic raceway systems that would form electrically inductive chokes shall not be used.

- G. Conductor connections shall be made by means of solderless connectors such as serrated bolted clamps or split bolt and nut type connectors.

3.2 SYSTEM DESCRIPTION

- A. Ground the electrical service neutral at service entrance equipment. Provide a main bonding jumper between the neutral and ground bus of the 480-volt main switchgear. Provide a separate grounding electrode conductor in conduit with grounding bushings on both conduit ends from the switchgear to the master ground bus-bar (MGBB) at the main electrical room. Bond MGBB to cold water metallic service pipe in contact with at least 10 feet of earth, and connect to opposite points of the building grounding ring (i.e. counterpoise) system by two main grounding conductors.
- B. Provide ground bus-bar, wall-mounted on insulated supports at 8'-0" AFF in electrical rooms, and radially connected to a master ground bus-bar in the main electrical room. See paragraph 3.5A, this Section.
- C. Separately Derived Systems: Ground the neutral of each separately derived system in accordance with NEC-250.30 and paragraph 3.3G, this Section.
- D. Provide communications system-grounding conductor at point of service entrance and connect to separate grounding electrode. Bond together the communications system grounding electrode and the electrical service-grounding electrode. Separate grounding systems without interconnecting bonds or jumpers are prohibited.
- E. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

3.3 SYSTEM GROUND

- A. System Neutral. Where a system neutral is used, ground the system neutral as required by NEC Article 250 and as indicated on Drawings. Ground the system neutral only at the point of service and isolate it from ground at all other points in the system.
- B. Size. Size the system grounding electrode conductors as indicated on plans.
- C. Separately Derived Systems. Ground neutrals of separately derived systems such as generators and transformers in accordance with NEC 250.30 and as indicated on Drawings.
 - 1. For each separately derived system, ground the neutral to system ground via the nearest ground busbar specifically provided for the purpose of grounding power distribution systems. Use unspliced grounding conductor from the neutral of the separately derived system to the ground busbar.
 - 2. Grounding conductors shall be as short and straight as possible, protected from mechanical damage, without splice or joint except as permitted by NEC 250.30 and paragraphs 3.1B and 3.3G.1 of this Section, above.
 - 3. Transformers: Bond the center point (neutral or XO terminal) of each wye-connected transformer to system ground at one point only. This point shall be ahead of the first overcurrent protective device (OCPD) connected to the secondary winding of the transformer. Refer to the applicable transformer specification for additional requirements.

3.4 EQUIPMENT GROUND

- A. Electrical Rooms: Provide a ground bus in electrical rooms, and at other locations indicated on Drawings.
 - 1. Mount busbar as indicated on plans..
 - 2. Connect busbar by grounding conductor to the main ground busbar at the main electrical room. Size grounding conductor as shown on Drawings. Where size is not indicated, use grounding conductor with cross-sectional area equivalent to the ground busbar.
 - 3. Connect to the ground bus noncurrent-carrying metallic parts of electrical equipment and enclosures in the room.
 - 4. Bond grounding conductors to the bus as further indicated on Drawings.

- B. Raceway Systems and Equipment Enclosures.
 - 1. Bond cabinets, cable trays, junction boxes, outlet boxes, motors, controllers, raceways, fittings, switchgear, switchboards, panelboards, transformer enclosures, other electrical equipment and metallic enclosures. Bond equipment and enclosures to the continuous-grounded, metallic raceway system in addition to other specific grounding shown. Ground each outlet by the use of an approved grounding clip attached to the outlet box in such a position to be readily inspected upon removal of the cover plate, or by the use of an approved grounding yoke type receptacle.
 - 2. Provide bonding jumpers and grounding conductors throughout the raceway system to ensure electrical continuity of the grounding system and the raceway.
 - 3. Provide grounding-type insulated bushings for metal conduits 1-1/2 inches and larger terminating in equipment enclosures containing a ground bus. Connect the bushing to the ground bus in the equipment enclosure.
 - 4. Provide a green insulated equipment grounding conductor for each feeder and branch circuit. Terminate each end of grounding conductor on a grounding lug, bus, or bushing.
 - 5. Provide internal grounding conductor on liquid tight flexible metal conduit ("sealtite") with ground bushings.
 - 6. Provide a flexible bonding jumper for isolated metallic piping and ductwork and around expansion fittings and joints.

- C. Size. Where grounding and bonding conductors are not sized on Drawings, size the grounding conductors in accordance with NEC Table 250.122. Size bonding jumper so that minimum cross-sectional area is greater than or equal to that of the equivalent grounding conductor as determined from NEC Table 250.122.

- D. Taps, Splices and Connections: Make grounding (earth) conductor approximately 2 inches longer than the ungrounded (phase) conductors at both ends.

3.6 FIELD QUALITY CONTROL

- A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.
- B. Testing: Test the completed grounding system by fall-of-potential method. Measure ground resistance from system grounding electrode main conductors to convenient ground reference point using suitable ground testing equipment.
 - 1. Prepare test procedures and test forms to be used for field testing of completed grounding system. Procedures and forms shall include documentation of test equipment proposed for use in field testing of completed grounding system.
 - 2. Resistance shall not exceed 1 ohm.
 - 3. Testing points shall include measurement of ground resistance from system neutral at electrical service entrance to convenient ground reference point using suitable ground testing equipment.
 - 4. Where measured resistance to ground exceeds 1 ohm, add additional ground rods to grounding system to achieve system resistance to ground of 1 ohm or less, and document measured resistance to ground after ground rods are added. Repeat as required to achieve resistance to ground of 1 ohm or less, at no additional cost to Owner.
- C. Documentation: Submit report of field testing of completed grounding system to Architect/Engineer and to Owner's Representative.

END OF SECTION

SECTION 26 05 29

METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of metal framing, including channels, fittings, clamps, hardware, electrical accessories and brackets.

1.2 SUBMITTALS

- A. None required.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Make channels, fittings, clamps, electrical accessories and brackets of sheet steel or of malleable cast iron. Fabricate threaded fasteners of carbon steel.

2.2 COATINGS

- A. Hot-dip galvanize all steel components utilized indoors. Provide stainless steel framing for outdoor applications.

2.3 SIZES

- A. Provide channels fabricated from not less than 12-gage sheet steel, 1-5/8 inches wide and not less than 1-5/8 inches deep.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Hot-dip galvanized steel shall be used in all areas except use stainless steel components when exposed to the weather, in the crawl space and when located in a corrosive atmosphere.

3.2 SUPPORTS

- A. Provide metal framing to support large or heavy wall-mounted equipment, wall-mounted raceways and ceiling-hung raceways. Use stainless steel channel to mount the exhaust fan disconnect switches on the roof. Supports shall be mounted independent of the fan enclosure. Secure support to roof.

3.3 ANCHOR BOLTS

- A. Use 1/2 inch diameter by 3 inches long expansion bolts to attach framing to concrete. Space bolts a maximum of 24 inches on center, with not less than two bolts per piece of framing.

3.4 TOUCH-UP

- A. Touch up all scratches or cuts on steel components with an approved zinc chromate or a 90 percent based zinc paint.

END OF SECTION

SECTION 26 05 33

RACEWAYS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of electrical raceway systems.

1.2 REFERENCE STANDARDS

- A. ANSI/ANSI C80.1 - Rigid Steel Conduit - Zinc-Coated.
- B. ANSI/ANSI C80.3 - Electrical Metallic Tubing - Zinc-Coated .
- C. ANSI/UL 1 - Flexible Metal Conduit.
- D. ANSI/UL 360 - Liquid-tight Flexible Steel Conduit.
- E. ANSI/UL 467 - Electrical Grounding and Bonding Equipment.
- F. ANSI/UL 797 - Electrical Metallic Tubing.
- G. ANSI/UL 870 - Wireways, Auxiliary Gutters and Associated Fittings.
- H. NEMA VE 1 - Metallic Cable Tray Systems.
- I. UL 6 - Rigid Metal Conduit.

PART 2 - PRODUCTS

2.1 CONDUIT AND FITTINGS

- A. Rigid Metal Conduit.
 - 1. Conduit. Rigid hot-dipped galvanized steel (RGS) conduit with zinc-coated threads and an outer coating of zinc chromate.
 - 2. Fittings. Threaded steel or malleable iron, either cadmium plated or hot-dipped galvanized.
- B. Electrical Metallic Tubing (EMT).
 - 1. Conduit. Galvanized electrical steel tubing.
 - 2. Fittings. Steel compression type or steel set screw fittings, either cadmium plated or hot-dipped galvanized. Connectors shall have insulated throat bushings.
- C. Rigid Nonmetallic Conduit.
 - 1. Conduit. Schedule 40 polyvinyl chloride (PVC).
 - 2. Fittings. Solvent weld socket type.
- D. Flexible Metal Conduit.
 - 1. Conduit. Spiral-wound, square-locked, hot-dipped galvanized steel strip.

2. Fittings. One-screw and two-screw for 1-1/2 inches and larger, double-clamp steel or malleable iron, either cadmium plated or hot-dipped galvanized.
- E. Liquid-tight Flexible Steel Conduit.
 1. Conduit. Spiral-wound, square-locked, hot-dipped galvanized steel strip plus a bonded outer jacket of PVC.
 2. Fittings. Compression type, malleable iron, with insulated throat, either cadmium plated or hot-dipped galvanized.
- F. Elbows.
 1. Provide large radius elbows.

2.2 WIREWAYS

- A. Material. Not less than 16-gage sheet steel.
- B. Dimensions. Cross section dimensions not less than 4 inches by 4 inches.
- C. Finish. Not less than two coats of enamel over a rust-inhibiting prime coat.
- D. Type.
 1. Indoors. NEMA 1.
 2. Outdoors. NEMA 4X.

PART 3 - EXECUTION

3.1 CONDUIT AND FITTINGS

- A. Minimum Trade Size. 3/4 inch, except that 1/2-inch flexible metal conduit may be used in lengths not exceeding 72 inches for tap conductors supplying lighting fixtures.
- B. Types According to Use.
 1. Use hot dipped galvanized rigid steel conduit (RGS) outside above ground where exposed to weather. Use RGS for 5Kv feeders. Rigid aluminum may also be used in lieu of rigid steel.
 2. Use EMT in interior walls or ceiling spaces and where exposed in open work areas, mechanical rooms or electrical rooms. Conduit that enters or leaves the top of panelboards or enclosures may be EMT, provided such panelboards and enclosures are located in mechanical or electrical rooms. EMT shall not be used for 5Kv feeders.
 3. Conduits may not be embedded in slabs without approval of the owner and the structural engineer.
 5. Connect all indoor electrical equipment subject to vibration or movement with flexible metal conduit 24 inches minimum length. Where the equipment is located in a duct or plenum used for environmental air, the length of conduit shall not exceed 4 feet and the conduit shall be flexible metal conduit. Where the equipment is located outdoors or exposed to water, liquid-tight flexible metal conduit shall be used.
 6. Transitions.

- a. Continue the heavier, more protective type conduit application not less than 4 inches into the area where lighter, less protective type conduit is permitted.
 - b. For below-grade to above-grade outdoor locations, extend concrete encasement around conduit 4 inches above finished grade and slope top away from conduit with a 6-inch-per-foot slope.
 - c. For below-grade to above-grade locations using PVC to metal conduit, make the transition from PVC to metal conduit before turning up with RGS elbow.
- C. Preparation. Place sleeves in walls and floor slabs for the free passage of cables or conduits. Set sleeves in place a sufficient time ahead of concrete placement so as not to delay the work. Seal all openings and voids around sleeves through floors and walls. Be sure that plugs or caps are installed before concrete placement begins.
- D. Installation Requirements.
1. Metallic conduits must be continuous between enclosures such as outlet, junction and pull boxes, panels, cabinets, motor control centers, etc. The conduit must enter and be secured to enclosures so that each system is electrically continuous throughout. Where knockouts are used, provide double locknuts, one on each side. For EMT terminations, provide insulated throat bushings and on rigid metallic conduits, provide nonmetallic insulating bushings for conductor protection. Where feeder conduits, 1-1/2 inches and larger, terminate in equipment having a ground bus, such as in switchgear, motor control centers and panelboards, provide conduit with an insulated grounding bushing and extend a suitable grounding wire to the ground bus.
 2. Have rigid nonmetallic conduit adequately solvent welded at joints to form a tight, waterproof connection.
 3. Run concealed conduit as directly and with the largest radius bends as possible. Run exposed conduit parallel or at right angles to building or other construction lines in a neat and orderly manner. Conceal conduit in finished areas. Unless otherwise shown, remaining conduit may be exposed. Provide chrome-plated floor and ceiling plates around conduits exposed to view and passing through walls, floors, partitions, or ceilings in finished areas. Select properly sized plates to fit the conduit when securely locked in place.
- E. Installation Methods.
1. Install each entire conduit system complete before pulling in any conductors. Clean the interior of every run of conduit before pulling in conductors to guard against obstructions and conduit omissions.
 2. Cut all joints square, then thread and ream smooth. Coat cuts, threads or scratches on steel conduit with an approved zinc chromate or with a 90 percent based zinc paint. When dry, draw up tight.
 3. Make bends with minimum 24" radius. Make field bends using equipment designed for the particular conduit material and size involved. Bends must be free from dents or flattening. Use no more than the equivalent of four 90-degree bends in any run between terminals and cabinets, or between outlets and junction boxes or pull boxes.
 4. Conduit bodies may be used in lieu of conduit ells where ease of installation and appearance warrants their use. Conduit bodies larger than 1 inch may be used only where approved.
 5. Securely fasten and support conduit to structure or metal framing using hot-dipped galvanized, malleable iron pipe straps or other approved means. Wires of any type may not be used for securing conduits. Branch circuit raceways which are 1 inch or smaller may be attached to wall studs by use of manufactured clips.
 6. Provide a No. 30 nylon pulling line in conduits in which wiring is not installed under this work. Identify both ends of the line by means of labels or tags reading "Pulling Line - Telephone," etc.
 7. Suitably cap conduit during construction to avoid water, dirt and trash entrance.

8. Use expansion-deflection fittings on conduit crossing structural expansion joints and on exposed conduit runs where necessary. Provide bonding jumpers across fittings in metal raceway systems.
9. Use expansion fittings in conduit that terminates at sensitive equipment.
10. With a coupling, terminate concealed conduit for future use at structural surfaces. Install a pipe plug flush with the surface.
11. Openings around electrical penetrations of fire-resistance rated walls, partitions, floors or ceilings shall be firestopped to maintain the fire resistance rating using approved methods.

3.2 WIREWAYS

- A. Install wireways, where shown, according to NEC Article 376. Field apply a 90 percent zinc paint coating over cuts or scratches before any other finish is applied.
- B. Maintain electrical continuity between sections of cable tray using manufacturer provided splice plates and bond cable trays at the both ends to building ground plates to provide a continuous grounding path. Install copper braided bonding jumpers around expansion joints and hinged adjustable splice plates where electrical discontinuity occurs. Install cable trays, where shown, according to NEC Article 392. Install cable trays in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 26 05 37

BOXES

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of outlet boxes, junction boxes and pull boxes.

1.2 REFERENCE STANDARDS

- A. ANSI/NEMA Publication No. OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers and Box Supports.
- B. ANSI/UL 514A - Metallic Outlet Boxes.
- C. ANSI/UL 514B - Fittings for Conduit and Outlet Boxes.

1.3 SUBMITTALS

- A. Provide product data.

PART 2 – PRODUCTS

2.1 OUTLET BOXES

- A. Flush Device Boxes. Provide galvanized steel boxes of sufficient size to accommodate wiring devices to be installed at outlet. Provide an extension ring for the device(s) to be installed. Square or rectangular boxes may be used. Unless otherwise noted, provide minimum 2-1/8-inch deep by 4-inch square minimum size box. For data outlets provide minimum 2-1/8-inch deep by 4-11/16 inch square minimum size box.
- B. Exposed or flush Device Boxes. Provide FS or FD cast boxes for surface mounting in areas having exposed rigid metal conduit systems.
- C. Boxes for Lighting Fixtures. Provide galvanized steel octagonal boxes with fixture stud supports and attachments as required to properly support ceiling and bracket-type lighting fixtures. Unless otherwise noted, provide 2-1/8-inch deep by 4-inch box.
- D. Masonry Boxes. Provide galvanized steel, 3-1/2-inch deep, masonry boxes for all devices installed in masonry walls.
- E. Switch Boxes. Not permitted.
- F. Listing. UL 514.

2.2 JUNCTION, PULL AND SPLICE BOXES

- A. Construction. Provide galvanized steel boxes conforming to NEC Article 314.

- B. Interior Spaces. Provide NEMA 1 type boxes at least 4 inches deep
- C. Exterior Spaces. Provide NEMA 4X type boxes at least 4 inches deep.
- D. Embedded. Provide NEMA 4 cast iron type with flush flanged cover when cast in concrete.
- E. Listing. UL 514.

PART 3 – EXECUTION

3.1 OUTLET BOXES

- A. Flush Boxes. Unless otherwise indicated, mount all outlet boxes flush within 1/4 inch of the finished wall or ceiling line. Provide galvanized steel extension rings where required to extend the box forward in conformance to NEC requirements. Attach ring with at least two machine screws. Securely fasten outlet boxes. Provide plaster covers for all boxes in plastered walls and ceilings.
- B. Fixture Boxes. Where boxes for suspended lighting fixtures are attached to and supported from suspended ceilings, adequately distribute the load over the ceiling support members.
- C. Mounting Height. Mounting height of a wall-mounted outlet box means the height from finished floor to horizontal center line of the cover plate. Where outlets are indicated adjacent to each other, mount these outlets in a symmetrical pattern with all tops at the same elevation. Where outlets are indicated adjacent, but with different mounting heights, line up outlets to form a symmetrical vertical pattern on the wall. Verify the final location of each outlet with Owner's representative before rough-in. Remove and relocate any outlet box placed in an unsuitable location.
- D. Back-to-Back Boxes. Do not connect outlet boxes back to back unless approval is obtained from the Owner's representative. Where such a connection is necessary to complete a particular installation, fill the voids around the wire between the boxes with sound insulating material.
- E. Box Openings. Provide only the conduit openings necessary to accommodate the conduits at the individual location.

3.2 JUNCTION AND PULL BOXES

- A. Installation. Install boxes as required to facilitate cable installation in raceway systems. Provide a junction box for terminating of flexible metal conduit to light fixtures. In general provide boxes in conduit runs of more than 100 feet.
- B. Covers. Provide boxes so that covers are readily accessible and easily removable after completion of the installation. Include suitable access doors for boxes above inaccessible ceilings. Select a practical size for each box and cover.
- C. Colors. Provide boxes with the following covers: Fire Alarm – Red, Emergency – Red, Security – White, Control – Blue.

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Nameplates and tape labels.
- B. Wire and cable markers.
- C. Conduit color coding and labeling.

1.2 REFERENCES

- A. NFPA 70 – National Electrical Code (NEC).

1.3 SUBMITTALS

- A. Provide submittals in accordance with and in additional to Section 26 00 00, Electrical General Provisions, and Division 01, for submittal requirements.
 - 1. Furnish nameplate identification schedules to Owner's Representative for review and acceptance, listing equipment type and nameplate data with letter sizes and nameplate material.
 - 2. Nameplate Schedules. Prior to fabrication of nameplates, furnish to Owner for review and acceptance a schedule of nameplates for electrical equipment. For each equipment and circuit identified, provide 4-line nameplate as follows:
 - a. Line 1: Device designation, switchgear or MCC cubicle, switchboard circuit, etc. as indicated on plans, schematics, or schedule Drawings.
 - b. Line 2: Leave blank for Owner's use.
 - c. Line 3: Source or voltage characteristics, as applicable.
 - d. Line 4: Load served.
 - 3. Refer to Parts 2 and 3 of this Section for nameplate requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Equipment Nameplates:
 - 1. For normal power electrical equipment, provide engraved three-layer laminated plastic nameplates, engraved white letters on a black background.
 - 2. For emergency equipment, provide engraved three-layer laminated plastic nameplates with engraved white letters on a red background.
 - 3. For UPS powered equipment, provide engraved three-layer laminated plastic nameplates with engraved white letters on an orange background.
 - 4. For fire alarm system, provide engraved three-layer laminated plastic nameplates with white letters on a yellow background.
 - 5. For security and CCTV system panels, provide engraved three-layer laminated plastic nameplates with white letters on a blue background.

6. Nameplate minimum size shall be 1 inch high by 3 inches long with engraved white letters. Generally, the number and name shall be at least 1/4 inch high and other data at least 1/8 inch high.
- B. Underground Warning Tape:
 1. Manufactured polyethylene material and unaffected by acids and alkalines.
 2. 3.5 mils thick and 6 inches wide.
 3. Tensile strength of 1,750 psi lengthwise.
 4. Printing on tape shall include an identification note "BURIED ELECTRIC LINE", and a caution note "CAUTION". Repeat identification and caution notes over full length of tape. Provide with black letters on a red background.
 5. Detector Strip. Metallic tape or similar detector strip, integral to warning tape.
- C. Conductor Color Tape and Heat Shrink:
 1. Colored vinyl electrical tape shall be applied perpendicular to the long dimension of the cable or conductor.
 2. In applications utilizing tray cable, heat shrinkable tubing shall be used to obtain the proper color coding for the length of the conductor in the cabinet or enclosure. Variations to the cable color coding due to standard types of conductor or cables are not acceptable.
- D. Conduit Labels (15 kV Conduits Only): 2-inch black letters on yellow background reading "DANGER - 4160 VOLTS", for example. Labels shall have adhesive backing, and shall be installed at intervals not exceeding 50 feet and on pull boxes located to be visible from floor.
- E. Warning labels: Provide warning labels with black lettering on red background with a minimum of 1/2 inch lettering.
- F. Tape Labels: Provide device labels of plastic adhesive tape, with minimum 1/4-inch letters for labeling receptacles, switches, control device stations, junction and pull boxes and manual motor starter units, etc.
 1. Normal power. Black letters on clear background. Provide white letters on black background where specifically indicated on Drawings or specified in other Sections.
 2. Emergency/standby power. Red letters on clear background. Provide white letters on red background where specifically indicated on Drawings or specified in other Sections.
 3. UPS power. Orange letters on clear background. Provide white letters on orange background where specifically indicated on Drawings or specified in other Sections.
 4. Provide device label with black letters, one half inch wide tape with one quarter inch high letters, minimum.
 5. Manufacturer. Brother type "P-Touch", or accepted substitution.
- G. J-Box and Cover plate Voltage Labels: Black stenciled letters 1/4 inch high. Adhesive back tapes may be used if a clear tape is applied over the label for protection.

PART 3 - EXECUTION

3.1 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in individually wrapped factory-fabricated fiberboard-type containers.

- B. Store materials in a clean and dry space, elevated above grade, and protected from weather and sunlight.
- C. Handle materials carefully to avoid damage, breaking, denting and storing. Damaged materials shall be rejected and shall not be installed.

3.2 INSTALLATION

- A. Degrease and clean surfaces to receive nameplates or tape labels.
- B. Install nameplates parallel to equipment lines.
- C. Secure plastic nameplates to equipment fronts using stainless steel self-tapping screws or rivets. Use of adhesives shall be per Owner's approval. Stick-on or adhesives will not be allowed unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates. Secure nameplate to outside face of flush mounted panelboard doors in finished locations.
- D. Designations: Externally mark equipment, feeders, branch circuits and similar items with nameplates with the same designations as indicated on the Drawings.

3.3 WIRE AND CONDUCTOR IDENTIFICATION

- A. Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, ground busbars and at load connection.
 - 1. Identify with branch circuit or feeder number for power and lighting circuits.
 - 2. Label control conductor with number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control wiring.
 - 3. Label grounding conductors at ground busbars, electrical equipment, and test wells with metal tags indicating the cable purpose and point of termination at opposite end of cable. Securely fasten metal tags along the length of the grounding cable or conductor. Place metal tags to avoid creating short circuits, inadvertent grounding paths, or other contact with grounded or energized terminals, conductors, or components.
- B. Existing Facilities. Where the Contractor encounters conductor identification in existing electrical distribution systems different from the colors scheduled in this Section, notify the Owner's Representative in writing and propose a resolution, in accordance with the requirements of Part 1 of Section 26 00 00, Electrical General Provisions.
- C. Conductors for power and lighting circuits shall be identified per the following schedule.

Conductor	480/277V	208/120V	Medium Voltage
Phase A	Brown	Black	One White Band
Phase B	Purple	Red	Two White Bands
Phase C	Yellow	Blue	Three White Bands
Neutral	Gray	White	N/A
Grounding	Green	Green	Green

- D. Where more than one conductor of the same phase or more than one neutral or ground conductor occurs at the same outlet or junction box, these conductors shall be identifiable from each other by use of stripes or distinguishing markings. The neutral tracer color shall match the phase conductor color with which it is associated.
- E. Switch leg conductors. Pink.
 - 1. The color of switch leg conductors shall be pink, marked with tape matching the color of the associated branch circuit phase conductors.
- F. Low voltage wiring systems. Conductors for low voltage circuits shall be identified as follows.
 - 1. Fire Alarm. Red
 - 2. Security. Blue and Yellow. Coordinate wiring color with Division 27 and telecommunications supplier
 - 3. Clock. Green and White
 - 4. Telephone. White. Coordinate wiring color with Division 27 and telecommunications supplier
 - 5. Data. Bright Blue. Coordinate wiring color with Division 27 and telecommunications supplier.
 - 6. HVAC Controls. Dark Blue. Coordinate wiring color with Division 23 and controls supplier.

3.4 NAMEPLATES

- A. Provide nameplates of minimum letter height as scheduled below. Nameplates shall be same as equipment names indicated on the Drawings.
 - 1. Externally mark electrical equipment with nameplates identifying each and the equipment served.
 - 2. Supply blank nameplates for spare units and spaces.
- B. Nameplate Fasteners. Fasten nameplates to the front of equipment by means of stainless steel self-taping screws. Stick-on or adhesives are not allowed unless the NEMA enclosure rating is compromised, then use only epoxy adhesive to attach nameplates.
- C. 5 KV-Class Switchgear.
 - 1. On main switches or circuit breakers: 3/8 inch: identify the equipment designation. 1/4 inch: identify system voltage and characteristics (i.e., 4.16 KV, 3PH, 3W).
 - 2. For each switch or circuit: 3/8 inch; identify the circuit or cubicle. 1/4 inch: identify the load served.
- D. 480-volt/208-volt Switchboard/switchgear:
 - 1. On the main switches or circuit breakers: 3/8 inch: identify the equipment designation. 1/4 inch: identify the source and voltage characteristics (i.e., 480/277V, 3PH, 4W).
 - 2. For each branch circuit protective device: 3/8 inch: identify the circuit or cubicle. 1/4 inch: identify the load served.
- E. Individual Circuit Breakers in Distribution Panelboards, Disconnect Switches, Motor Starters, and Contactors: 1/4 inch: identify source to device and the load it serves, including location.

- F. Dry Type Transformers Not in Substations: 3/8 inch: identify equipment designation. 1/4 inch: identify primary and secondary voltages, primary source, and secondary load and location.
- G. Panelboards: 3/8 inch: identify equipment designation. 1/4 inch: identify source, voltage and bus rating.
- H. Provide complete circuit directory for each new panel board. Provide complete circuit directory for each existing panelboard with circuits added, removed, demolished, moved, renovated, or otherwise altered as part of this project or as work required by or incidental to this project. Refer to Section 26 24 16 for directory requirements.
- I. Identification tags on items in finished areas, such as special switches, etc., shall be securely attached on, or in the immediate vicinity, of the item. Supply blank nameplates for spare units and spaces.

3.5 ENCLOSURE COLOR CODING

- A. The following systems shall have each enclosure and cover completely painted as follows:
 - 1. Fire Alarm. Red, with black "FA" text.
 - 2. Emergency Power. Red, with black "E" text.
- B. The following systems shall have each junction and pull box cover completely painted per the following:

System	Color of Box Cover
Telecommunications	Brown
DDC	Green
Emergency Power	Red, with black "E" text
Security**	White
Fire Alarm	Red, with black "FA" text

**Security shall include, but not be limited to, the following systems:

- Card Access
- Duress Alarms
- Perimeter Door Alarms

- C. CCTV

3.6 EQUIPMENT AND DEVICE MARKING

- A. Pull, Junction and Outlet Boxes.
 - 1. With 1/2-inch high permanent lettering, identify conduits connected to pull, junction and outlet boxes with the complete circuit number of the conductors contained therein. Identify complete circuit numbers on box cover and on the conduit.

2. Where multiple circuits are contained in a box, identify the circuit conductors with permanent tags which indicate circuit designation. Identify both phase and associated neutral conductors.
 3. Boxes and covers containing emergency power or emergency lighting circuits shall be painted red. Factory finish is acceptable in lieu of painting in the field. No other raceway, conduit, boxes, or enclosures shall be painted red.
 4. Fire alarm boxes and covers shall be painted red. Using permanent lettering, identify box cover as "F/A" or "FAS", with fire alarm zone served. Factory finish is acceptable in lieu of painting in the field. No other raceway, conduit, boxes, or enclosures shall be painted red.
- B. Equipment and Raceways Over 600 Volts: Provide "WARNING - HIGH VOLTAGE - KEEP OUT" signs on equipment. With 2-inch-high lettering, mark exposed raceways containing conductors operating in excess of 600 volts every 50 feet, or in each room or space or compartment of penetration, and at each wall or floor penetration, with the words "WARNING - HIGH VOLTAGE -13,200 VOLTS".
- C. Power Receptacles: Use a clear plastic tape label, nameplate or engraved device plate to identify power receptacles where the nominal voltage between a pair of contacts is greater than 150 volts with circuit number, voltage and phases. If nameplates are used, attach to wall directly above device plate. Nominal 120 volt power receptacles shall be labeled with the complete circuit number.
- D. Snap Switches:
1. Where the equipment served is not in sight of the snap switch, or where snap switch controls dedicated outlets or special equipment, provide a clear plastic tape label or an engraved switch plate to identify equipment served.
 2. Where snap switches are grouped together, provide clear plastic tape labels or engraved switch plates to identify non-lighting equipment served.
- E. Dedicated Outlets: For dedicated outlets, provide a clear plastic tape label or an engraved cover plate indicating the equipment served. Dedicated is understood to be specific equipment listed by equipment number in the panel schedules or identified on the plans. Dedicated also includes computer outlets.
- F. Remote Ballasts: For remote ballasts not within five feet of their luminaire, provide appropriate permanent lettering on both the ballasts and the luminaire to identify which units are mated to the other.

END OF SECTION

SECTION 26 05 73

SHORT-CIRCUIT/COORDINATION STUDY

PART 1 GENERAL

1.1 SUMMARY

- A. Provide a complete short-circuit and protective device coordination study for the emergency/standby power electrical distribution systems. The extent of the study shall be from the existing Centerpoint Energy(CNP) main service on the normal side and the new generator for the standby/emergency portion. The study shall include all new equipment. An arc flash study is not required. The arc flash study will be completed by the project engineer.

1.2 SUBMITTALS

- A. A preliminary short-circuit study shall be submitted to the design engineer either before or at the same time as the equipment submittals. If equipment submittals such as switchgear, switchboards, panelboards etc. are submitted without a preliminary study, they will be returned Rejected. .
- B. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. The report shall include the following sections:
 - 1. Executive Summary.
 - 2. Descriptions, purpose, basis and scope of the study.
 - 3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties.
 - 4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection.
 - 5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout.
 - 6. Recommendations for system improvements, where needed.
 - 7. One-line diagram.

1.3 REFERENCES

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems.
 - 2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 - 3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis.
 - 4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings.
 - 5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
- B. American National Standards Institute (ANSI):
 - 1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.
 3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
 4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.
- C. The National Fire Protection Association (NFPA)
1. NFPA 70 - National Electrical Code, latest edition.
 2. NFPA 70E – Standard for Electrical Safety in the Workplace.

1.4 QUALIFICATIONS

- A. The short-circuit and protective device coordination studies shall be conducted under the supervision and approval of a Licensed Professional Electrical Engineer licensed in the state of Texas and skilled in performing and interpreting the power system studies.
- B. The Licensed Electrical Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm and have a minimum of five (5) years of experience in performing power system studies. In addition, the licensed engineer shall be based and work in the Houston, Tx area.

1.5 COMPUTER ANALYSIS SOFTWARE

- A. The studies shall be performed using the latest revision SKM Systems Analysis Power Tools.

PART 2 PRODUCTS

2.1 DATA COLLECTION

- A. The Contractor shall be responsible for collecting all data for the studies except as follows. CNP fault current information has been provided at the end of this specification. Existing relay settings have been provided on the one line diagrams. The contractor is responsible for all other data collection.

2.2 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

- A. Provide a short circuit study for all new equipment.
- B. Provide the following:
1. Calculation methods and assumptions.
 2. Selected base per unit quantities.
 3. One-line diagram of the system being evaluated.
 4. Source impedance data, including electric utility system and motor fault contribution characteristics.
 5. Tabulations of calculated quantities.
 6. Results, conclusions, and recommendations.
 7. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a line to ground fault at each piece of equipment/bus as described in 1.01.
- C. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings.
 2. Adequacy of all equipment to withstand short-circuit stresses.
- D. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.
- E. Transformer design impedances shall be used only when test impedances are not available.

2.3 PROTECTIVE DEVICE COORDINATION STUDY

- A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs. The phase curves shall be plotted on separate sheets from the ground fault curves. For the normal power side, the PDC study shall begin at existing switchgear PSWGRA and extend downstream to all new devices. For the standby/emergency system, the study shall begin at the new generator and extend downstream to all new devices. A new breaker will be installed in PSWGRA and connected to an existing Cutler Hammer Digitrip 3000 relay. The CH 3000 relay values shall be set per the study. The existing CH 3000 relay values for the main breakers in PSWGRA/B are noted at the end of this specification for reference. In addition, all relays in new paralleling switchgear PSE and all new 480V/208V circuit breakers shall be set per the study. Any existing relays in switchgear PSWGRA/B that are being reused shall also be set for the new load.
- B. Plot the following characteristics on the TCC graphs where applicable:
1. Equipment name based on Bid documents.
 2. Electric utility's overcurrent protective device.
 3. Medium voltage (4.16kV) equipment overcurrent relay settings.
 4. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 5. Low voltage (480V/208V and below) equipment circuit breaker trip device settings, including manufacturer's tolerance bands.
 6. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 7. Ground fault protective devices, as applicable.
 8. Pertinent motor starting characteristics and motor damage points, where applicable.
 9. Pertinent generator short-circuit decrement curve and generator damage point.
- C. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.4 ARC FLASH HAZARD ANALYSIS-NOT REQUIRED

2.5 REPORT SECTIONS

- A. Input data shall include, but not be limited to the following:
1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).
 2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
 3. Reactor data, including voltage rating, and impedance.

4. Generation contribution data, (synchronous generators and Utility), including short-circuit sub-transient reactance (X''^d), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio.
 5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.
- B. Short-Circuit Output Data shall include, but not be limited to the following reports:
1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
 - a. Voltage.
 - b. Calculated fault current magnitude and angle.
 - c. Fault point X/R ratio.
 - d. Equivalent impedance.
 2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
 - a. Voltage.
 - b. Calculated symmetrical fault current magnitude and angle.
 - c. Fault point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
 - e. Equivalent impedance.
 3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
 - a. Voltage.
 - b. Calculated symmetrical fault current magnitude and angle.
 - c. Fault point X/R ratio.
 - d. No AC Decrement (NACD) Ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis.
- C. Recommended Protective Device Settings:
1. Phase and Ground Relays:
 - a. Current transformer ratio.
 - b. Current setting.
 - c. Time setting.
 - d. Instantaneous setting.
 - e. Recommendations on improved relaying systems, if applicable.
 2. Circuit Breakers:
 - a. Adjustable pickups and time delays (long time, short time, ground).
 - b. Adjustable time-current characteristic.
 - c. Adjustable instantaneous pickup.
 - d. Recommendations on improved trip systems, if applicable.

PART 3 EXECUTION

3.1 FIELD ADJUSTMENT

Short Circuit and Protective Device Coordination Study

- A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

CNP DATA



MAJOR UNDERGROUND FAULT DUTY & PROTECTION DATA FORM

FACILITY UT Medical School		CNP WORK CENTER VT0046		ADDRESS 6431 Fannin		DATE PREPARED 12/4/2015					
CONTACT NAME HENDRICKSON, STEVEN		CONTACT EMAIL steven.hendrickson@centerpointenergy.com		CONTACT PHONE 713-207-6242		CONTACT FAX					
SYSTEM FAULT DUTY DATA											
Fault Data Reference Point:				SERVICE TRANSFORMER PRIMARY							
BASE VALUES		THEV IMPEDANCE		LLL FAULT		LG FAULT					
Power [MVA]	Voltage [KV]	R ₁ [pu]	X ₁ [pu]	R ₀ [pu]	X ₀ [pu]	Current [A]	X/R				
100	34.50	MIN	0.02700	0.20390	0.05090	0.19570	8,136				
		MAX	0.02840	0.18240	0.05260	0.17300	9,066	7.55			
						6.42	9,148				
							5.75				
							4.92				
SERVICE TRANSFORMER DATA											
ID	kVA	%Z	VOLTAGE		WINDING CONFIGURATION						
			Primary	Secondary	Primary		Secondary				
TR-1	5,000	6.77	34,500	4160Y/2400	<input type="checkbox"/> DELTA <input type="checkbox"/> WYE <input checked="" type="checkbox"/> GND'd WYE	<input type="checkbox"/> DELTA <input type="checkbox"/> WYE <input checked="" type="checkbox"/> GND'd WYE					
TR-2	5,000	6.84	34,500	4160Y/2400	<input type="checkbox"/> DELTA <input type="checkbox"/> WYE <input checked="" type="checkbox"/> GND'd WYE	<input type="checkbox"/> DELTA <input type="checkbox"/> WYE <input checked="" type="checkbox"/> GND'd WYE					
NEAREST UPSTREAM PROTECTION DATA											
FUSE	RATING	MFR	CAT#								
OR											
PHASE RELAY (51L/51N/50L) per transformer	MFR SEL	CAT# 451-2	VOLTAGE 34,500	51L TAP [A] 1.20	CURVE U3	TIME DIAL 2	51N TAP [A] 0.50	CURVE U3	TIME DIAL 3	50L TAP [A] 11.00	CT RATIO 120
GROUND RELAY (51G) per transformer	MFR SEL	CAT# 501	VOLTAGE 4,160	51L TAP [A] 4.00	CURVE U3	TIME DIAL 3	51L TAP [A]	CURVE	TIME DIAL	50L TAP [A]	CT RATIO 120
NOTES											
GENERAL DISCLAIMER											
The fault data provided is based on the existing configuration of the electrical distribution system at the time the data was generated and is subject to change as modifications are made to the utility system. CenterPoint Energy does not warrant the accuracy of the furnished data beyond the time at which it was calculated, and disclaims all liability or damages of any kind that may result from the use of this information for any purpose.											

EXISTING PSWGRA/B MAIN BREAKER RELAY DATA

PSWGR-A AND B MAIN BREAKERS

PHASE SETTINGS

PHASE CT RATIO	1200:5
TAP PICKUP 51P1P	0.8
CURVE SHAPE	I2T
TIME MULT	10
INST (xCT)50P1P	N/A
SHORT TIME PICKUP	1.75
SHORT TIME DELAY	1

GROUND SETTINGS

GROUND CT RATIO	200:5
TAP PICKUP 51N1P	1
CURVE SHAPE	G-FLAT
TIME MULT	0.7
INST (xCT)50P1P	N/A
SHORT TIME PICKUP	9
SHORT TIME DELAY	1

END OF SECTION

SECTION 26 22 13

HIGH EFFICIENCY K-7 TRANSFORMERS (US DOE 2016)

PART 1 - GENERAL

1.1 SUMMARY

- A. Copper-wound transformers meeting US Department of Energy 2016 mandated minimum efficiency. These transformers shall be UL listed to feed a K-7 electronic equipment load profile and be optimized to minimize operating cost under light loading.
- B. Compliance with full specification is required
- C. Transformers shall meet the following requirements:
 - 1. Efficiencies must meet or exceed the US DOE 2016 minimum requirement
 - 2. No load losses must comply with those defined in this specification
 - 3. Efficiency at low load and under nonlinear load must meet the minimum requirements of this specification
 - 4. K-7 listing per UL 1561 is required, see plans.
 - 5. Comprehensive testing under linear and nonlinear loading is required to verify specified performance . Performance submittals are required
- D. The Work under this Section is subject to requirements of the Contract Documents including the Uniform General Conditions, Supplementary General Conditions, and Division One Sections.
- E. All work covered by this Section shall be accomplished in accordance with all applicable provisions of the Contract Documents and any addenda or directives which may be issued herewith, or otherwise.
- F. Drawings and general provisions of the Contract, including Terms and Conditions, Supplementary Conditions, Special Conditions, and other Division One Sections, apply to this Section.

1.2 REFERENCES

- A. US Department of Energy, 10 CFR Part 431, April 18, 2013. Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule
- B. DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A to Subpart K of 10 CFR part 431.
- C. ANSI/NEMA ST 20 - Dry Type Transformers for General Applications.
- D. NEMA Premium Efficiency Transformers Program
- E. Consortium for Energy Efficiency (CEE): Specification for Low-Voltage, Dry- Type Distribution Transformers

- F. EPACT 2005 - United States Energy Policy Act 2005 / NEMA TP1 - Guide for Determining Energy Efficiency for Distribution Transformers
- G. ANSI/NEMA TP-2 – Standard Test Method for Measuring Energy Consumption of Distribution Transformers
- H. IEEE C57.110-1998 – IEEE Recommended Practice for establishing transformer capability when feeding nonsinusoidal load currents
 - 1. IEEE Std C57.12.91-1995 Standard Test Code for Dry-Type Transformers
- I. IEEE-1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
- J. LEED – Leadership in Energy and Environmental Design, U.S. Green Building Council.
- K. ISO 9001:2008 – International Standards Organization - Quality Management System
- L. ISO 14001:2004 – International Standards Organization - Environmental Management System
- M. ISO 17025 – International Standards Organization - General requirements for the competence of testing and calibration laboratories

1.3 RELATED SECTIONS

- A. Section 26 05 26, Grounding and Bonding.
- B. Section 26 05 33, Raceways.
- C. Section 26 05 29, Metal Framing and Supports.
- D. Section 26 05 73, Overcurrent Protective Device Coordination Study.

1.4 SUBMITTALS

Submit product data including the following:

- A. Test Reports per US DOE 10 CFR Part 431, NEMA TP2, of previously manufactured units – representative of the kVA range on the project, tested in ISO 17025 Certified Efficiency Test Lab, signed by test engineer, documenting history of production capability to comply with performance requirements of this specification.
- B. Test Reports per factory ISO Nonlinear Load Test Program, signed by factory test engineer of previously manufactured units – representative of the kVA range on the project, tested in ISO 17025 Certified Efficiency Test Lab, documenting history of production capability to comply with performance requirement of this specification.
- C. Construction details including enclosure dimensions, kVA rating, primary & secondary nominal voltages, voltage taps, BIL, unit weight
- D. Basic Performance characteristics including insulation class, temperature rise, core and

- coil materials, impedances & audible noise level, unit weight
- E. Documentation of UL listing of 1/2" clearance from ventilated surfaces
- F. Inrush Current (typical 3 cycle recovery)
- G. Short Circuit Current data: Primary & Secondary
- H. Efficiency, Loss & Heat output Data
- I. No load and full load losses per NEMA ST20
- J. Linear load data @ 1/6 load
- K. Linear load data @ 1/4, 1/2, 3/4 & full load
- L. Linear Load efficiency @ 35% loading tested per NEMA TP-2.
- M. Efficiency under K7 load profile at 16.7%, 25%, 50%, 75%, 100% of nameplate rating.
- N. Factory ISO 9001 procedure describing nonlinear load test program
 1. Meter and CT details including model, accuracy, serial numbers and calibration information.
- O. Copy of ISO 14001:2015 Certification
- P. Copy of ISO 9001:2008 Certification or manufacturer's own certification showing compliance with the ISO certification.
- Q. Documentation that materials used for shipment packaging meet the environmental requirements of this specification.

1.5 NONLINEAR LOAD TEST PROGRAM

- A. Nonlinear Load Testing shall be carried out by an ISO 17025 Certified Efficiency Test Lab, and follow a defined protocol, independently audited within the ISO system.
- B. Efficiency shall be determined purely by measurements following IEEE Std C57.12.91-1995 Standard Test Code for Dry-Type Transformers. Other methods are not acceptable.
- C. The nonlinear load bank shall consist of phase-neutral equipment with a K-7 profile, representative of a mix of typical office receptacle loads.
- D. Meters and CTs shall both be revenue class accurate and carry current calibration certificates. CTs shall be operated within their approved accuracy loading range. Dual meters shall gather simultaneous primary and secondary energy and harmonic data. Meter and CT details including model, accuracy, serial numbers and calibration information.
- E. Efficiency: Measurements shall be taken at multiple load levels and plotted to show compliance with specification and correlation to the designed efficiency curve.

- F. Harmonic data including current and Voltage THD at the different load levels shall be included with the test report.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Store and protect products
- B. Store in a warm, dry location with uniform temperature. Cover ventilation openings to keep out dust, water and other foreign material.
- C. Handle transformers using lifting eyes and/or brackets provided for that purpose. Protect against unfavorable external environment such as rain and snow, during handling.

1.7 WARRANTY

- A. In addition to the requirements of Division One and Section 26 00 00, provide 18 month pro-rated warranty against defects in materials and workmanship, with limited liability.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS/PRODUCT

- A. Square D, Cutler Hammer, General Electric, Powersmiths International Corp.
- B. Manufacturers wishing to have products evaluated for acceptability and conformance with the performance requirements of this specification, shall provide detailed compliance and/or exception statements, along with the documentation required in the submittal section, including test documentation, signed by an engineer, that confirms that the transformer(s) meets the specified performance.
- C. Failure to provide the required documentation no less than 7 days prior to the bid date will disqualify products from consideration for this project.

2.2 RATINGS

- A. Compatibility: This product must facilitate the ability of the electrical system to supply a sinusoidal voltage in order to improve the long-term compatibility of the electrical system with all types of linear and nonlinear connected loads today and in the future. All national and international standards on harmonics and power quality set limits on levels of voltage distortion to maintain compatibility.
- B. Copper-wound, 3-phase, common core, ventilated, dry-type, isolation transformer built to UL1561, NEMA ST20 and other relevant NEMA, UL and IEEE standards; 200% rated neutral; 60Hz rated; Transformers 750 kVA and less, 600 volt primary and less, shall be UL Listed and CSA Approved. All terminals, including those for changing taps, must be readily accessible by removing a front cover plate. Windings shall be continuous with terminations brazed or welded. 10kV BIL.
- C. Insulation System:

1. Shall be NOMEX-based impregnant for lowest environmental impact, long term reliability and long life expectancy.
 2. Class: 220 degrees C
 3. Impregnant Properties for low emissions during manufacturing, highest reliability and life expectancy
 4. Epoxy co-polymer
 5. VOC: less than 1.65 lbs/gal (low emissions during manufacturing)
 6. Water absorption (24hrs @25C): less than 0.05% (superior insulation, longer life)
 7. Chemical Resistance: Must have documented excellent performance rating by supplier
 8. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
 9. Dissipation Factor: max. 0.02 @25C to reduce aging of insulation, extending useful life
- D. Operating Temperature Rise: 115 degree C in a 40 degree C maximum ambient
- E. UL Listed & Labeled K-Rating: K-7 or higher
- F. Enclosure type: Indoor Ventilated NEMA 1, drip-proof [or select other: sprinklerproof, outdoor padmount, secure, outdoor public, totally enclosed, stainless steel]
- G. Rear Clearance: UL Listed for 6" clearance minimum from the wall. This capability shall be explicitly described on the nameplate of each unit.
- H. Exceed minimum efficiency requirements of US Department of Energy, 10 CFR Part 431, April 18, 2013, Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule which takes effect January 1, 2016, and comply with the table of Maximum No Load Losses, efficiency requirements at 1/6 load, efficiency at 35% load per 10 CFR Part 431, and efficiency at 35% load under a K-7 load profile. THIS NEEDS UPDATING. WAITING FOR INFO FROM OTHER MANUFACTURERS

kVA	No load losses (Watts)	Efficiency @ 1/6 load (%)	Efficiency @ 35% load (%)	Efficiency at 25% load under K-4,K7 nonlinear load
15	47	97.85%	98.28	98.00%
20	60	98.05%	98.34	98.10%
25	66	98.15%	98.41	98.15%
30	71	98.27%	98.50	98.30%
45	97	98.40%	98.66	98.40%
50	112	98.45%	98.67	98.42%
63	120	98.50%	98.75	98.48%
75	135	98.63%	98.82	98.60%
100	180	98.65%	98.88	98.65%
112.5	195	98.70%	98.92	98.70%
125	215	98.73%	98.94	98.72%
150	235	98.80%	98.99	98.80%
175	270	98.82%	99.02	98.82%
200	310	98.84%	99.05	98.84%

225	330	98.90%	99.09	98.90%
250	365	98.91%	99.10	98.92%
300	400	98.95%	99.15	99.00%
400	530	98.96%	99.20	99.02%
450	600	98.97%	99.22	99.03%
500	650	99.00%	99.25	99.05%
600	800	99.01%	99.28	99.07%
750	875	99.10%	99.32	99.10%
850	950	99.11%	99.34	99.11%
1000	1200	99.12%	99.36	99.12%

- I. Voltage Taps: For transformers 15kVA-300kVA, provide two 2-1/2% full capacity taps above and four 2-1/2% taps below nominal primary voltage. For transformers 500 and 750KVA, provide two 2-1/2% full capacity taps above and two 2-1/2% taps below nominal primary voltage.
- J. Impedance: Between 3.0% and 6.0% unless otherwise noted.
- K. Grounding: Ground the core of the transformer to the enclosure with a flexible grounding conductor sized according to NEC requirements.
- L. Infrared (IR) Viewing Port to address NFPA 70E/CSA-Z462 Arc Flash Standard
 - 1. Provide integrated IR viewing port that provides single point viewing point that enables the thermal scanning of all live connections including primary and secondary feeder terminations and taps without requiring opening of the transformer enclosure or exposure to live parts.
 - 2. The port shall be easily usable by a wide variety of makes and models of commercially available thermal scanning devices, without requiring any proprietary connectors, adapters or other components.
- M. Lug Kit: supply with Compression lugs configured as specified at time of order

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

- A. Delivery. Deliver transformers individually wrapped for protection and mounted on shipping skids.
- B. Storage. Store transformers in a clean, dry space, elevated above grade, and protected from weather, moisture, sunlight, and dirt. Maintain factory wrapping or provide an additional heavy canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Temporary Heating. Apply temporary heat for protection from insulation moisture absorption and metallic component corrosion in accordance with paragraph 3.2B of Section 26 00 00, Basic Electrical Requirements, and according to manufacturer's written instructions.

tions. Apply temporary heat within the enclosure of each ventilated-type unit throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.

- D. Stacking. Do not stack transformers.
- E. Work Surface. Transformers shall not be used as work tables, scaffolds, platforms, or ladders.
- F. Handling. Handle transformers carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damaged transformers shall be rejected and not be installed on project.
- G. General Provisions. Refer to Part 3 of Section 26 00 00, Basic Electrical Requirements.

3.2 INSPECTION

- A. Installer shall examine the areas and conditions under which dry type transformers are to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

- A. Install dry type transformers in locations indicated on Drawings, in accordance with the applicable requirements of the NEC, NEMA, and ANSI.
- B. Set transformers plumb and level.
- C. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.
- D. Ventilation.
 - 1. Provide adequate clearance around transformer for ventilation of core, coil and internal components; minimum 1 foot – 0 inch all sides unless noted otherwise.
 - 2. Where transformers are proposed for installation vertically one above the other, provide sufficient vertical separation between transformers to permit adequate air circulation for proper cooling of each transformer, in accordance with manufacturer recommendations. Take temperature measurements of transformers under load and document temperature rise and temperature of each transformer where mounted in a vertical arrangement. Where the temperatures exceed manufacturer's recommendations or the requirements of this Section, relocate transformers to provide adequate cooling.
- E. Verify removal of coil shipping anchor bolts before transformer is energized.
- F. Check for damage and tight connections prior to energizing transformer.

3.4 FLOOR MOUNTING

- A. Provide concrete pad for floor-mounted transformers. Refer to structural Drawings and specifications for design criteria. Where not otherwise indicated, and in addition to the requirements of Section 26 00 00, Electrical General Provisions, and Section 26 05 29, Metal Framing and Supports, construct pads of nominal 4 inch thick 2500 pound concrete reinforced with 6 inch x 6 inch steel wire mesh. Size pads 3 inches wider than transformer and chamfer edges to a 3/4 inch bevel.
- B. Maintain a minimum of 12 inches free air space between enclosure and walls.
- C. Vibration isolation. Provide vibration and sound isolation system suitable for isolating the transformer noise from the building structure.
 - 1. Provide spring-type isolators in suspension system sized to support the transformer weight, one at each corner of transformer lower mounting rails. Manufacturer: Korfund/Aeroflex type LK, or accepted substitution.
 - 2. Use one pad type Korfund Elasto-Grip, waffle, or accepted substitution, at each corner of the transformer, below the spring-type isolators, sized for load of 50 lbs./sq.-in.
- D. Secure the transformer and vibration isolators to the pad as recommended by the manufacturer.
- E. Refer to Section 26 05 29, Metal Framing and Supports.

3.5 CONDUIT CONNECTIONS

- A. Flexible Metallic Conduit. Attach incoming and outgoing conduits to the transformer enclosure with flexible metallic conduit (FMC), minimum length 24 inches.
 - 1. Make conduit connections to side panel of enclosure using an appropriately sized 90-degree elbow connector.
 - 2. Provide grounding-type coupling at each end of flexible metallic conduit. Provide a bonding jumper on outside of flexible conduit, sized per NEC Table 250.122 or NEC Table 250.66 as appropriate. The exterior bonding jumper shall be provided in addition to the grounding conductor run with the transformer circuit conductors inside the conduit. Where grounding conductor or jumper size is shown larger on Drawings, provide the larger size.
- B. Liquid Tight Flexible Metallic Conduit. Where indicated, use liquid-tight flexible conduit for connections to transformer case, maximum length 6 feet, minimum length 3 feet, with slack or dip to attenuate noise transmitted through conduit.
 - 1. Make conduit connections to side panel of enclosure using an appropriately sized 90-degree elbow connector.
 - 2. Provide grounding-type coupling at each end of liquid-tight flexible conduit. Provide a bonding jumper on exterior of liquid-tight flexible conduit, sized per NEC Table 250.122 or NEC Table 250.66 as appropriate. The exterior bonding jumper shall be provided in addition to the grounding conductor run with the transformer circuit conductors inside the conduit. Where grounding conductor or jumper size is shown larger on Drawings, provide the larger size.

3.6 CABLE CONNECTIONS

- A. Lugs. Make transformer cable connections with compression-type lugs suitable for termination of 90°C rated conductors. Position lugs so that field connections and wiring will not be exposed to temperature above 75°C.
- B. Grounding. Ground the neutral (X0) of the transformer secondary winding in accordance with the requirements of NEC-250.30, paragraph 3.3G of Section 26 05 26, and as indicated on Drawings. Connect equipment grounding conductors, system bonding jumper(s), and isolated grounding conductors to transformer neutral (X0) bus. Provide equipment bonding jumper from transformer neutral (X0) bus to transformer metallic enclosure. Expose bare metal of transformer enclosure to ensure proper contact between transformer enclosure and equipment bonding jumper.

3.7 TAP SETTING

- A. Check for damage and tight connections prior to energizing transformer. Verify removal of all shipping anchor bolts and shipping supports prior to energizing transformer.
- B. Measure primary and secondary voltages and make appropriate tap adjustments.
- C. Select the appropriate tap setting on transformer so that the actual secondary voltage is $\pm 1/2$ of a tap span at full load.

3.8 TESTING

- A. Test and record no-load amperages of all dry type transformers. Replace at no cost to Owner all transformers with no load amperage exceeding four percent of rated full load.
- B. Submit record of field testing and tap settings to the Owner's Representative and to the Architect/Engineer, in accordance with the requirements of Division One and Section 26 00 00. Where not specified elsewhere, provide three copies of the record.

END OF SECTION

SECTION 26 23 00

LOW-VOLTAGE METAL-ENCLOSED DRAWOUT SWITCHGEAR

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of low-voltage metal-enclosed drawout switchgear with low voltage power circuit breakers. The switchgear is part of a substation lineup.

1.2 REFERENCE STANDARDS

- B. NEMA SG-3 - Low-Voltage Power Circuit Breakers.
- C. NEMA SG-5 - Power Switchgear Assemblies.
- D. ANSI C37.13 - Low-Voltage AC Power Circuit Breakers.
- E. ANSI C37.16 - Preferred Rating for Low-Voltage Power Circuit Breakers.
- F. ANSI C37.20 - Switchgear Assemblies Including Metal-Enclosed Bus.
- G. ANSI C37.50 - Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
- H. ANSI C37.51 - Standard for Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies.
- I. NEMA PB1.2 - Application Guide for Ground Protective Devices for Equipment.
- J. UL 1558 (1993) - Standard For Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

1.3 SUBMITTALS

- K. Brochures. Submit brochures on the switchgear, main protective device, branch circuit protective devices and instrumentation.
- L. Dimensional Drawings. Submit dimensional drawings of the switchgear, including top and bottom views showing entry and exit space for conduits and busways, front and side elevations showing arrangement of all devices and also include dimensional data on all buses including material type and capacity of the buses.
- M. Electrical Information. Submit three line diagrams for equipment being provided. Also submit information on all protective devices including type, ratings and settings of all trips provided including ground fault relay settings.
- N. Coordination curves for each type and rating of circuit breaker.

PART 2 – PRODUCTS

2.1 DESCRIPTION

- A. General. Provide completely factory assembled freestanding metal-enclosed drawout switchgear assembly from incoming line lugs to load terminals of all protective devices. Include all necessary buses, supports, devices and provision for future connections as shown. *Equipped spaces shall have the same provisions as breaker occupied spaces.*
- B. The switchgear shall fit in the space shown on the plans.
- C. Acceptable Manufacturers. Square D, GE, Cutler Hammer

2.2 RATINGS

- A. Voltage Characteristics. 480Y/277 and 208Y/120volts, three phase, 4 wire, 60 hertz, see plans. .
- B. Main Bus. As indicated on the drawings.
- C. Available Short Circuit Current. As indicated on the drawings.
- D. Device Ratings. As indicated on the drawings.

2.3 ENCLOSURE

- A. Construction.
 - 1. Fabricate the switchgear enclosure with the required number of vertical sections nominally 90 inches high, 72 inches deep and width as shown on drawings. Bolt vertical sections together to provide a rigid, freestanding, metal-enclosed unit which must withstand all shipping, handling and installation procedures without damage or deformation. Provide NEMA 2 (drip-proof) enclosure.
 - 2. Completely enclose the frame with removable, bolted, code-gauge sheet steel covered panels and hinged doors. Form all cover plates and doors to eliminate sharp edges.
- B. Access.
 - 1. In general, the switchgear shall be composed of three compartments front to back. The front compartment being the instrument or circuit breaker compartment, the middle compartment being the bus compartment and the back compartment being the cable compartment. Front and rear access is required.
 - 2. Provide adequate wiring gutter space at the top, bottom and sides for easy access to all wiring terminations.
- C. Device Mounting.
 - 1. Provide a unit with individually mounted protective devices.
 - 2. Assembly must permit interchanging devices of the same type, rating and method of operation.
- D. Lifting Provisions.
 - 1. Provide permanent lifting means on top of shipping sections.

2. Include an integral roll-along lifting device for switchgear equipped with drawout devices. Mount lifting device on top of switchgear.
- E. Finish. Grind all steel surfaces smooth, with all burrs, sharp edges, welding splatters, loose rust, scale and the like totally removed after fabrication. Following this, chemically clean and treat steel work to allow a good bond between the steel surfaces and apply a rust-preventive primer paint. After priming, thoroughly paint the inside and outside with a suitable finish paint. Supply 1 pint of finish paint for each switchgear for touch-up after installation.

2.4 BUSES

- A. Main, Section and Branch Bus.
 1. Material. Fabricate all buses of 98 percent IACS conductivity, tin- or silver-plated copper with rounded edges. Make all connections using a minimum of two bolts.
 2. Design.
 - a. Rate main bus for currents shown on drawings.
 - b. Determine current rating for section bus and branch bus on the basis of service to all devices including spares and spaces for future addition. Size section bus a minimum of 60 percent of the main bus rating.
 - c. Size all buses to limit their temperature rise within the switchgear to 65°C based on a 40°C outside ambient temperature.
 - d. Size all buses so that current density will not exceed 1000 amperes per square inch.
- B. Neutral Bus. In each switchgear section, include an uninsulated neutral bus on insulated bus supports secured to the section frame and bolt to neutral bus bars in adjacent sections, thus providing a continuous neutral bus.
- C. Ground Bus. In each switchgear section, include an uninsulated copper ground bus bar for the equipment. Secure the bar to the unit frame and bolt to the ground bus bars in adjacent sections, thus providing a continuous equipment ground bus. Arrange the equipment ground bus to ground the switchgear parts which do not carry current. Include terminations at the bus bar for feeder and branch circuit grounding conductors. The terminations must be exothermically welded on or be of an approved pressure connector type. Make area of ground bus not less than 1.00 square inches.
- D. Length. Extend all buses the entire length of the switchgear. Buses must have the required capacity for their total length. Make provisions for extensions from either end of buses.
- E. Insulators. Support main, section and branch bus systems with insulators to provide short circuit bracings. Use non-carbonizing, non-tracking insulators.
- F. Lugs. Lugs for incoming and outgoing feeders shall be crimp type compression lugs. For the two main incoming feeders provide lugs to terminate up to 12 conductors per phase.

2.5 DEVICE AND BUS ISOLATION

- A. Isolate vertical buses from each other using insulating barriers. Provide insulating barriers between vertical and main bus and between main bus and load terminal. Include barriers at rear and sides of individually mounted devices. Provide horizontal barriers for complete compartmentalization of individually mounted devices.

2.6 TRIP UNITS

- A. Each drawout low-voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of four current sensors (one for residual sensing of neutral current), microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are ratings of each circuit breaker. The trip unit shall have an information system that provides LEDs to indicate mode of trip following an automatic trip. A red trip reset button shall be provided to turn off the LED indication after an automatic trip.
- B. The trip unit shall be provided with a display panel, including a representation of the time/current curve of the trip unit, which indicates the protection function settings. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
- C. Complete system selective coordination shall be provided by the individually adjustable time/current curve shaping solid-state elements indicated on the drawings.
- D. When the adjustable instantaneous setting is omitted, the trip unit shall be provided with a discriminator or making-current release circuit to prevent closing the circuit breaker on a faulted system.
- E. The trip unit shall contain an integral test panel with a test selector switch and a test pushbutton. A potentiometer shall be provided to enable the user to select the values of test currents within a range of available settings. The basic protection functions shall not be affected during test operations. The breaker may be tested in the Trip or No Trip test mode.
- F. The trip unit shall contain a keyed receptacle for use with an Auxiliary Power Module (APM). The APM, when connected to a 120V, 60 Hz source, shall provide power for testing the trip unit while the breaker is out of the cell or in the disconnect position. Provide two APM units per assembly.
- G. Trip unit shall have thermal memory for enhanced circuit protection.
- H. ZSI-Provide zone selective interlocking between main and feeder breakers.

2.7 MAIN PROTECTIVE DEVICE

- A. Type. As the main protective device for the switchgear, provide a 100 percent rated, 3-pole, low-voltage, non-fused power circuit breaker.
- B. Operating Mechanism. Stored energy, quick-make, quick-break type.
- C. Characteristics.
 - 1. Mounting. Drawout.
 - 2. Operation. Electrically operated open and closed.
 - 3. Trip. Long time, short time, instantaneous and ground fault.

- D. Accessories.
 - 1. Mechanical pushbutton trip and indicator.
 - 2. Provisions for padlocking in the open position.
- E. Acceptable Manufacturers. Square D company Masterpact breaker and Micrologic Trip unit

2.8 TIE BREAKER

- A. Type. As the tie breaker for the switchgear, provide a 100 percent rated, 3-pole, low-voltage, nonfused power circuit breaker.
- B. Operating Mechanism. Stored energy, quick-make, quick-break type.
- C. Characteristics.
 - 1. Mounting. Drawout.
 - 2. Operation. Electrically operated open and closed.
 - 3. Trip. Long time, short time, instantaneous and ground fault.
- D. Accessories.
 - 1. Mechanical pushbutton trip and indicator.
 - 2. Provisions for padlocking in the OPEN position.
- E. Acceptable Manufacturers. Square D company Masterpact breaker or equal

2.9 FEEDER PROTECTIVE DEVICE

- A. Type. As the branch circuit for the switchgear, provide a 100 percent rated, 3-pole, low-voltage, nonfused power circuit breaker.
- B. Operating Mechanism. Stored energy, quick-make, quick-break type.
- C. Characteristics.
 - 1. Mounting. Drawout.
 - 2. Operation. Electrically operated open and closed.
 - 3. Trip. Long time, short time, instantaneous and ground fault.
- D. Accessories.
 - 1. Mechanical pushbutton trip and indicator.
 - 2. Provisions for padlocking in the OPEN position.
- E. Acceptable Manufacturers. Square D company Masterpact breaker or equal

2.10 DIGITAL INSTRUMENTS (MULTI-METER TYPE)

- A. Type. Solid-state circuit monitor, Square D Power-Logic ION 7650 for the Mains or equal.
- B. Functions. As a minimum, the following functions shall be metered:
 - 1. Phase volts.
 - 2. Phase amperes.
 - 3. kW with maximum demand.
 - 4. kW/phase.
 - 5. kVA/phase.
 - 6. kVAR/phase.

7. kWH.
 8. kVAH.
 9. kVARH.
 10. Power factor.
 11. kVA with maximum demand.
 12. Frequency.
 13. Individual harmonics.
 14. Total harmonic distortion.
- C. Accuracy (Minimum Requirements).
1. Current and voltages: $\pm 0.20\%$.
 2. Frequency, power, demand and energy: $\pm 0.40\%$.
 3. Power factor: $\pm 1.0\%$. Accuracy shall be maintained from 3-300% of full scale, and -0.5 to 1.00 to +0.5 for power factor.
- D. Special Requirements. See plans for networking of meters.

2.11 CONTROL DEVICES

- A. Types. Provide control devices consisting of control switches, pushbuttons, interlocks, and wiring as may be required for the operating mechanism which moves the breaker to and from the operating position; auxiliary relays and switches, complete with all wiring and mechanisms required for the particular manufacture of the breaker; operation counter; manually operated trip bar or lever; and provisions for manual closing.
- B. Control and Instrument Switches and Pushbuttons. Use control and instrument transfer switches of the multiple-stage, rotary, heavy-duty, switchboard type. Supply momentary contact spring-return breaker control pushbuttons (close, trip) with hinged transparent safety cover. Supply maintained contact instrument switches with round handles. Electro switch type W or approved equal for switches, and Square D 30mm Type K or approved equal for pushbuttons.
- C. Indicating Lights. Provide each breaker control switch with a red 30mm (closed) LED and a green (tripped) LED indicating light.
- D. All breakers in the switchgear shall be electrically operated. Each breaker shall be able to be operated (open/close) by a permanent remote pushbutton/selector switch station. Locate switches in a NEMA 1 cabinet/box. Provide a total of three NEMA 1 boxes, one each for switchgear USHC A/B, USLB A/B and USHXB A/B. In addition, provide a red and green LED light for each breaker for position indication, green for breaker open, red for breaker closed. Provide a terminal block for Side A breakers and a terminal block for Side B breakers. Wire breakers to terminal blocks and locate in cubicle above main breaker.
- E. Provide a remote racking device to allow for remote insertion and removal of all circuit breakers from the chassis between the disconnected position and the connected position.

2.12 CONTROL WIRING

- A. Wiring. Install and test control and small wiring inside the switchgear at the factory, including breaker control wiring, instrument wiring, secondary leads from instrument transformers, etc. Neatly and carefully install interior wiring in suitable wiring gutters or conduit, using SIS standard 600-volt switchboard-type, stranded copper wire No. 14 AWG or larger. Identify each wire at terminals by means of permanent sleeve-type wire marker. Secure wiring from hinged doors and panels to enclosure in a manner to allow ample flexibility in bending. All

current transformers secondary leads shall first be connected to conveniently accessible short circuit terminal blocks before connecting to any other devices.

- B. Terminals. Terminate wire on instruments, devices, transformers and 600-volt rated terminal blocks by means of ring-tongue type connectors under screws, marked in accordance with the manufacturer's wiring diagram. Locate terminal blocks in readily accessible places. No more than two ring-tongue terminals shall be allowed at any terminal block or other connection point within the switchgear.
- C. Spare Contacts. Wire spare contacts to suitably identified terminals for external connections and clearly show these connections on shop drawings.
- D. Spare Terminals. In addition to specified spare contact terminals, provide not less than 10 percent spare terminals on each terminal block provided.
- E. Key Interlocks as indicated on the drawings.

2.13 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16 inch high, minimum.
- B. Furnish Master nameplate giving switchgear designation, year manufactured, voltage ampere rating, short circuit rating, manufacturer's name, general order number and item number.
- C. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's shop drawings.

2.14 LISTING

- A. The switchgear shall be UL 1558 listed and shall be suitable for use as service entrance equipment.

2.15 FACTORY TESTING

- A. The switchgear shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchgear shall be tested to assure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities. The manufacturer shall notify the Owner's Representative two weeks prior to the date the tests are to be performed.
- B. The manufacturer shall provide certified copies of factory test reports per Section 01300, SUBMITTALS.

1.4 SURGE ARRESTOR

- A. Refer to Specification section 26 43 13 for surge arrestor requirements.

1.1 INFRARED VIEWING PORT

- A. Provide infrared viewing ports at the rear of switchgear to allow for infrared scanning of all cable connections.

PART 3 – EXECUTION

3.1 PROTECTION OF SWITCHGEAR

- A. See Section 26 05 00.

3.2 FOUNDATION PAD

- A. Provide a foundation pad for the load bank switchgear only as specified in Section 26 05 00, Electrical General Provisions. Secure the switchgear to the pad as recommended by the manufacturer. Include openings for bottom feeds to the switchgear which are compatible with the equipment provided. The switchgear located on the new metal platform does not require a pad. The contractor is responsible for leveling the switchgear on the metal platform per manufacturer's tolerances as required.

3.3 EQUIPMENT INSTALLATION

- A. Field Connections. Make field connections of buses between switchgear sections with splice bus and hardware provided by the switchgear manufacturer.
- B. Equipment Settings. Properly set adjustable current, voltage and time settings as noted on shop drawing submittals. Effectively accomplish grounding and bonding. For switchgear located on the new metal platform, bond the switchgear to the platform with 1#4/0 bare conductor.
- C. Restoration. Restore all damaged surfaces to factory finish.
- D. Inspection. Thoroughly inspect the switchgear for items such as loose connections and presence of foreign materials and remedy prior to energizing the switchgear. All bolted connections shall be torqued to the manufacturer's recommendations.
- E. Double Lugging. Double lugging on one protected device to feed two separate loads will not be permitted.
- F. Installation. The Contractor is responsible for insuring the switchgear selected fits the space shown on the plans and over the structural supports shown on the structural plans. The switchgear shall not exceed the dimensions of the switchgear shown on the plans.

3.4 TESTING

- A. After installation and before acceptance by the Owner's Representative, the Contractor shall provide the services of an independent testing organization (independent from the Contractor) to performance test all ground fault trips in accordance with NEC paragraph 230-95. This test shall involve passing a primary current through the current sensor with a suitable, low voltage test set and timer, which shall allow verification that the trip units track their published curves and that they actually trip the devices on which they are applied. This test shall also include the polarity of the current sensors and give an indication of satisfactory operation of all instruments.

- B. The Contractor shall notify the Owner's Representative of this test date two weeks in advance so the tests can be properly witnessed.

END OF SECTION

SECTION 26 24 16

PANELBOARDS – DISTRIBUTION AND BRANCH CIRCUIT

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of distribution and branch circuit panelboards. See 26 43 15 and one line diagrams for installation of surge protective device in distribution panelboards. The panelboard used for the main service shall be service entrance rated.

1.2 REFERENCE STANDARDS

- B. ANSI/UL 50 - Cabinets and Boxes.
- C. ANSI/UL 67 - Electric Panelboards.
- D. ANSI/UL 508 - Industrial Control Equipment.
- E. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
- F. NEMA AB 3 - Molded Case Circuit Breakers and Their Application.
- G. NEMA PB 1 - General Instructions for Proper Handling, Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

1.3 SUBMITTALS

- H. Provide product data on panelboards, circuit breakers and remote control switches.
- I. Provide shop drawings with a schedule for each panelboard that indicates the circuit breaker arrangement and other pertinent features. Panelboard schedules must be identical to the schedules in the project documents unless there is a technical reason for a deviation. Submitted panelboard schedules must also contain confirmation of panelboard characteristics.

PART 2 – PRODUCTS

2.1 ENCLOSURE

- A. Cabinet. Construct cabinets in accordance with UL 50. Use not less than 16-gauge galvanized sheet steel. Provide a minimum 4-inch gutter wiring space on each side. Reinforce cabinets and securely support bus bars and over-current devices to prevent vibration and breakage in handling. Provide cabinets without conduit knockouts. All conduit knockouts shall be made in the field. Surface-mounted panelboards in finished spaces shall have cabinet finishes to match doors and trim as specified below. In unfinished areas such as mechanical and electrical rooms, galvanized sheet steel cabinets are sufficient, provided galvanizing occurs after components are cut or sheared.

- B. Doors and Trim. Provide cabinets with single door, dead-front construction. The door shall have a continuous piano hinge on the right side and shall provide access only to circuit breaker operating handles. Removal of trim shall allow for full access to the cabinet interior. Fabricate doors and trim of cold-rolled sheet steel. Equip inner doors with flush-type combination catch and key lock. Key all locks alike. Fasten trim for panelboards to cabinets by an approved means that permits both horizontal and vertical adjustment. Trim for surface-mounted panelboards must fit the cabinet with no overhang. Apply a finish to trim and doors consisting of two coats of enamel over a rust-inhibiting prime coat.

2.2 BUS

- A. Fabricate phase, neutral and ground buses of 98 percent IACS conductivity copper with rounded edges. Size bars as indicated and brace them to withstand symmetrical short circuit current as indicated on drawings. Install buses in allotted spaces so that devices can be added without additional machining, drilling or tapping. Use buses with silver-plated contact surfaces. This applies to all standard panels and electronic grade panelboards. Provide a ground bus rated as required. Provide an additional isolated ground bus where indicated on plans.

2.3 PROTECTIVE DEVICES

- A. Provide circuit breakers for the specified service with the number of poles and ampere ratings indicated.
- B. Provide breakers that are quick-make and quick-break on both manual and automatic operation. Use a trip-free breaker that is trip indicating. Incorporate inverse time characteristic by bimetallic overload elements and instantaneous characteristic by magnetic trip. Where indicated, provide ground fault circuit interrupters (GFCI). Main circuit breakers 400A and above in all panelboards shall be 100% rated. Main breakers below 400A and feeder breakers may be 80% rated. Provide electronic trip on the Main breaker, Long time, Short time, instantaneous and ground fault. **Provide electronic trip for feeder breakers 200A and larger; Long time, Short time, Instantaneous and ground fault.** Note that plans may not necessarily indicate LSIG on breakers, however, LSIG is still required as noted in this specification.
- C. For 2-pole and 3-pole breakers, use the common-trip type so that an overload or fault on one pole will trip all poles simultaneously. Handle ties are not acceptable.
- D. Unless otherwise indicated on plans, provide circuit breakers with the following interrupting ratings: 65,000 rms symmetrical amperes at rated voltage for breakers rated 277 volts, single pole or 480 volts, multipole and 65,000 rms symmetrical amperes at rated voltage for breakers rated 120V, single pole or 208 volts. Series rating of circuit breakers is not allowed. All circuit breakers shall be fully rated, unless indicated otherwise.
- E. Connect breakers to the main bus by means of a solidly bolted connection. Use breakers which are interchangeable, capable of being operated in any position within the panel. Independently mount breakers so that a single unit can be removed from the front of the panel without disturbing or removing main bus, other units or other branch circuit connections.
- F. Cable lugs shall suitable for copper or aluminum conductors.

2.4 CIRCUIT IDENTIFICATION

- A. For each panelboard, provide a steel directory frame mounted inside the door with a heat-resistant transparent face and a directory card for identifying the loads served. Type directory as specified in Section 26 00 00, paragraph 3.3.

2.5 LISTING

- A. UL 67 - Electric Panelboards.

2.6 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are Eaton Electrical (Cutler-Hammer), Square D, GE Company.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Install panelboards in the locations shown and as recommended in NEMA PB1.
- B. Surface mounted panels shall be mounted to the wall utilizing 1 5/8" hot dipped galvanized framework. Do not mount panels directly to the wall.

3.2 MOUNTING HEIGHT

- A. Install the panelboards 6' aff to top of panelboard.

3.3 PROTECTION

- A. Temporary Doors. Protect cabinets by a temporary door until the panelboard is energized. Temporary doors shall be 1/4-inch-thick plywood or equivalent rigid material. Temporary doors shall be installed when the cabinet is installed and shall remain closed at all times except when work is being performed inside the panelboard.
- B. Permanent Doors and Trim. Permanent doors and trim shall be installed immediately before panelboards are energized. Permanent doors and trim shall be maintained in factory condition after installation. Doors shall remain closed at all times except when the panelboard is de-energized and work is taking place within the panelboard.
- C. Cabinets. Cabinet interiors shall be maintained clean at all times. Cabinet exteriors shall be maintained free of mud, spray-on insulation, paint spray and all substances not placed on the exterior surface by the panelboard manufacturer.

END OF SECTION

SECTION 26 25 00

BUSWAY – 600 VOLT AND BELOW

PART 1 – GENERAL

1.1 WORK INCLUDED

- A. This Section specifies the furnishing and installation of low voltage Busway systems. The new busway system shall be a General Electric Spectra series due to the fact the busway will connect to existing General Electric Armorclad busway.

1.2 REFERENCE STANDARDS

- A. ANSI/IEEE C37.20 - Switchgear Assemblies Including Metal Enclosed Bus.
- B. ANSI/UL 857 - Busways and Associated Fittings.
- C. NEMA BU-1 - Busways.

1.3 APPLICABLE PROVISIONS

- A. Refer to Section 26 01 00, Basic Electrical Requirements.

1.4 SUBMITTALS

- A. Submit manufacturer's product data.
- B. Submit dimensioned drawings of busway.
- C. Submit floor plan showing routing of entire busway run including connection to existing busway.

PART 2 – PRODUCTS

2.1 TYPE

- A. Furnish non-ventilated feeder and plug-in bus with voltage and ampacity ratings indicated on the drawings. Note that under this package only the busway will be provided. Plug-in breakers will be provided in a future package.

2.2 HOUSING

- A. Fabricate housing of sheet steel or aluminum. Provide adequate mechanical protection for the conductors and include mounting rails for attaching hangers at any point. Paint housings with two coats of enamel over a rust-inhibiting primer. Protect hardware with a corrosion-resistant plating.

2.3 BUS BARS

- A. Busway housing shall be extruded aluminum for maximum protection against corrosion from

water and other contaminants normally encountered during construction. Housing shall be totally enclosed for protection against mechanical damage and dust accumulation. All hardware shall be silver plated to prevent corrosion.

- B. Insulation. All bus bar insulation material shall be epoxy NEMA Class B (130 degree C). Insulation shall be UL rated as self-extinguishing and shall be impervious to acids, alkalis, acetones, machine oils and lubricants commonly found in industrial environments. Manufacturer shall provide test data documenting insulation's impact resistance, chemical resistance, and expected life (50 years). Voltage Drop. Line-to-line voltage drop on feeder bus shall be less than 3.50 volts per 100 linear feet at rated current, with 0.9 pf and concentrated loading. Line-to-line voltage drop on plug-in bus shall be less than 2.75 volts per 100 linear feet at rated current, with 0.9 pf and distributed loading.
- C. Minimum Short Circuit Rating. The bus shall be braced to withstand a short circuit as indicated on plans.

2.4 FITTINGS

- A. Compatibility. Provide fittings which are the manufacturer's standard products designed specifically to be compatible with the busway provided.
- B. Expansion Fittings. Provide expansion fittings where busways cross building expansion joints and where runs exceed 200 feet in length.

2.5 PLUG-IN UNITS

- A. None required. All busway shall be feeder busway only.

2.6 ACCESSORY MATERIALS

- A. Provide beneflex wall flanges and fire stops at busway penetrations of floors and required fire-rated walls.
- B. Provide splice plates, clamp-type hangers, and hardware for proper support of the busway throughout its length.

2.7 LISTING

- A. UL 857 - Busways and Associated Fittings.

2.8 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers:
 - 1. General Electric – No substitutions

2.9 MARKING

- A. The Busway shall be marked in accordance with NEC 368.

PART 3 – EXECUTION

3.1 FIELD MEASUREMENTS

- A. Verify dimensions at job site to ensure coordination of each busway with obstructions and approved routing. Submit fully dimensioned shop drawings indicating proposed routings and fittings prior to start of fabrication. All field verification shall be done by a GE factory engineer in conjunction with the contractor.

3.2 INSTALLATION

- A. Support the busway in accordance with NEC 368. Do not install supports so that joint is placed in tension, compression or torsion. Design joints so that any section can be removed without disturbing adjacent lengths. Also design the joints so each can be made from one side if the bus is installed against a wall or ceiling. Connect bus bars together in accordance with manufacturer's instruction.
- B. The contractor is responsible for connecting the new Spectra busway to the existing horizontal section of Armorclad busway based on existing field conditions.
- C. Horizontal busway shall be UL listed to hand on 10 foot centers in any position.
- D. Provide UL listed 2 hour fire stopping where busways pass through walls.
- E. Megger busways using 1000VDC megger, Check phase to phase and phase to ground.
- F. Install busway per manufacturer's instructions.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of wiring devices and device plates.

1.2 REFERENCE STANDARDS

- A. Americans with Disabilities Act (ADA).
- B. ANSI/IEEE 62.41 - Guide for Surge Voltages in Low-Voltage AC Power Circuits.
- C. ASHRAE 90.1-2004 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- D. NEMA WD 1 - General Requirements for Wiring Devices.
- E. NEMA WD 2 - Semiconductor Dimmers for Incandescent Lamps.
- F. NEMA WD 5 - Specific-Purpose Wiring Devices.
- G. NFPA 70 - National Electrical Code (NEC).
- H. Texas Accessibility Standards (TAS).
- I. ANSI/UL 20 - General-Use Snap Switches.
- J. ANSI/UL 498 - Attachment Plugs and Receptacles.
- K. ANSI/UL 943 - Ground Fault Circuit Interrupters.
- L. UL 1449 - Transient Voltage Surge Suppressors.

1.3 RELATED WORK

- A. Section 26 00 05, Electrical General Provisions.
- B. Section 26 05 37, Boxes.
- C. Section 26 05 53, Electrical Identification.
- D. Section 26 51 00, Interior and Exterior Lighting.

1.4 SUBMITTALS

- A. Provide product data on wiring devices and device plates.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide back- and side-wired, industrial-grade, factory-fabricated wiring devices in the type and electrical rating for the service indicated. Where type and grade are not indicated, provide proper selection to correspond with branch circuit wiring and overcurrent protection. Attachment of wires to devices shall be by screw pressure under the head of binding screws or by means of a factory made, listed, plug-style connector. Plug-style connector shall be touch safe while connected to branch circuit conductors and manufactured to mount at 90-degree angle to direction of insertion to allow easy mounting in outlet boxes. Arrangements depending on spring pressure or tension are not acceptable. All binding screws shall be brass or bronze..
- B. Grade. Provide industrial-grade devices unless otherwise noted or specified.
- C. Type. Provide straight-blade devices as specified herein and as indicated on Drawings. Provide locking-type receptacles (i.e., Twist-Lock) in corridors or other special type receptacles where indicated on Drawings.

2.2 WALL SWITCHES

- A. Type. Quiet type, back and side wired switches as shown.
- B. Rating. 20 amperes, 120/277 volts, unless indicated or specified otherwise.
- C. Finished Areas. Wall switches shall be toggle-style switches. Select device plates of same color, and match with receptacle, phone and data outlet device plate style. Coordinate with Architect and Owner for room finish.
- D. Listing. UL 20 and Federal Specification W-S-896.
- E. Manufacturers. The following designations are for white devices; provide devices in the color specified in paragraph 2.4, this Section.

Type	Cooper	Bryant	Pass & Seymour	Hubbell	Leviton
S	1991W	4901W	PS20AC1-W	HBL1221W	1221-2W
S2	1992W	4902W	PS20AC2-W	HBL1222W	1222-2W
S3	1993W	4903W	PS20AC3-W	HBL1223W	1223-2W
S4	1994W	4904W	PS20AC4-W	HBL1224W	1224-2W
SK	-L	-L	-L	-L	-L

- 1. Key operated switch: add the indicated suffix to the above designations.
- F. Pilot light type shall be equipped with red toggle handle (glow when on), 20 amperes and 120/277 volt AC with number of poles as required.
- G. Key operated switches shall be 20 amperes and 120/277 volt AC with number of poles as required. Key locks alike. Furnish keys compatible with key switch, quantity as directed by Owner, minimum of ten copies.

- H. Switches for lighting circuits and motor loads under 1/3 hp shall be AC general use snap switch with toggle handle, 20 amperes and 120/277 volt AC with number of poles as required.
- I. A listed manual switch having a horsepower rating not less than the rating of the motor, a thermal overload element suitable for the motor served, and marked "Suitable as Motor Disconnect", shall be permitted to serve as the disconnect means for stationary motors of 1/4 horsepower or less.
- J. Use horsepower rated switches, with thermal overload element, approved for motor control or disconnect service when controlling or disconnecting motor loads in excess of 1/4 hp. Horsepower rated switches shall be 30 ampere minimum, with number of poles as required.
- K. EPO. Illuminated Emergency-Power-Off (EPO) switch shall be provided with button guard equal to Allen-Bradley #800T-QA10R or accepted substitution.
- L. Switch terminal screws or connectors shall be designed to accommodate up to No. 10 AWG solid conductor.

2.3 RECEPTACLES

- A. Type. Back and side wired receptacles.
- B. Rating. As scheduled on Drawings.
 - 1. Dedicated circuit and convenience duplex receptacles shall be rated 20 amperes, 125 volt AC, where not scheduled or indicated otherwise on Drawings.
 - 2. Ground Fault Circuit Interrupter (GFCI or GFI). Refer to paragraph 2.3F, this Section.
- C. Listing. UL 498 and Federal Specification W-C-596.
- D. Manufacturers. The following designations are for white devices or manufacturer's standard device color; provide devices in the color specified in Article 2.4, this Section. Other manufacturers equal in design and function will be considered upon submittal of manufacturer's data.

			Pass &		
NEMA Config.	Cooper	Bryant	Seymour	Hubbell	Leviton
5-20R	5362	5362	5362-AW	5362	5362A-W
GFCI	GF8300	GFR83FT	2094-W	GF-8300	8899-W

- E. Heavy Duty Locking-Blade Receptacles. NEMA WD 5. Locking-blade receptacles shall be heavy duty specification grade.
- F. Ground Fault Circuit Interrupter (GFCI). GFCI receptacles shall be rated 20 amperes, 125 volt with integral ground fault current interrupter.
 - 1. End of Life. GFCI receptacles shall include End-of-Life protection, such that when the GFCI device is incapable of passing the internal self-test function, and can therefore no longer provide ground fault protection, the GFCI receptacle will either render itself incapable of delivering power, or indicate by visual or audible means that the device must be replaced
 - 2. Reverse Line-Load Miswire. GFCI receptacles shall include reverse line-line protection, such that the GFCI device will deny power to the receptacle face if it is mis-wired with the connections to the line and load terminals reversed.
 - 3. Listing. UL 943, current edition.
 - 4. Do not use feed through feature.

5. GFCI receptacles are required throughout the building within 6 feet of sinks, including lab areas.
 6. Each GFCI device shall control only one receptacle.
 7. Where receptacle is installed in damp or wet locations provide weather resistant type GFCI receptacles.
- G. Specific-use receptacles shall have volts, amps, poles, and NEMA configuration as noted on Drawings.
- H. Weatherproof Receptacles. Receptacles specified or indicated as "weatherproof" shall be mounted in a cast steel box with gasketed, weatherproof device plate as specified. Provide weatherproof, gasketed device covers suitable for continuous connection of cord-and-plug devices. See paragraph 2.5E, this Section.

2.4 DEVICE COLOR

- A. Supply wiring devices in white, except where device color is specified or scheduled on Drawings, and as noted below:
1. Wiring devices connected to emergency power shall be red.
 2. Isolated ground receptacles shall be orange.
 3. Key operated switches shall be gray.
- B. Coordinate color of devices and device plates with the architectural finish for that room or area. Refer to architectural Drawings and specifications. Verify color and finish with Architect and Owner's Representative.
- C. For renovation or expansion of existing facilities, provide devices and plates to match existing finishes, devices, and device plates.

2.5 DEVICE PLATES

- A. Finished Spaces.
1. Provide high abuse and impact resistant nylon device plates, with cutouts as required for devices indicated on Drawings. Edges of plates must be flush with edges of boxes.
- B. Color.
1. Device plates for receptacles connected to emergency power shall be red.
 2. Device plates for receptacles connected to normal power shall be white.
 3. Where not specified or indicated otherwise, provide device plates in white.
- C. Where switches or outlets are shown adjacent to each other, they shall be ganged with partitions between different type services and covered by a single custom wall plate.
- D. Jumbo plates are not permitted.
- E. Weatherproof enclosures.
1. For each GFCI receptacle specified in 2.3F and installed in wet locations, provide a weatherproof enclosure cover per NEC 406.9B(1) (Leviton 5977 DGR).
- F. Exposed Boxes in Dry Interior Spaces. Make plates of heavy cadmium-plated sheet steel. Edges of plates must be flush with edges of boxes. Screws and fasteners shall be stainless steel.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

- A. Deliver wiring devices individually wrapped in factory-fabricated containers.
- B. Handle wiring devices carefully to avoid breaking, scoring, and damage to material components, enclosure and finish. Damaged products shall be rejected and not be installed on this project.
- C. Store wiring devices in a clean, dry space, elevated above grade, and protected from weather, dirt, sunlight, and moisture.
- D. Refer to paragraph 3.2 of Section 26 00 00, Electrical General Provisions.

3.2 INSPECTION

- A. Examine the areas and conditions under which wiring devices are to be installed and notify the Owner and the Architect/Engineer in writing of conditions detrimental to the proper and timely completion of the work. Include a written plan for correction of deficiencies and conditions noted. Inspect devices for physical damage. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.3 DEVICE COORDINATION

- A. Where items of equipment are provided under other Sections, by other Divisions, or by the Owner, provide a compatible receptacle and device plate for the cap or plug, and cord of the equipment.

3.4 GENERAL

- A. Install wiring devices in accordance with applicable requirements of the NEC, NEMA, ANSI, and the product manufacturer recommendations.
- B. Taps, Splices and Connections. Make grounding (earth) conductor approximately 2 inches longer than the ungrounded (phase) conductors at both ends. Refer to Section 26 05 26, Grounding and Bonding.
- C. Termination. Stranded conductors for branch circuit wiring to snap switches and receptacles shall terminate at the wiring device with an insulated tin-plated copper spade compression terminal. Select a spade terminal compatible with the wiring devices supplied so that device screw terminals can be torqued to the wiring device manufacturer's recommendations. Refer to Section 26 05 19, Insulated Conductors.
- D. Where more than one device occurs in one outlet box, such that the voltage between adjacent devices would exceed 300 volts, provide a barrier for isolation to comply with the requirements of NEC Article 404.8(B).
- E. Location. The approximate location of switches, power outlets, floor boxes, etc., is indicated on the Drawings. These Drawings, however, may not give complete and accurate information in regard to locations of such items. Determine exact locations by reference to the general building Drawings and by actual measurements during construction of the building before rough in, subject to the approval of the Constructor Inspector and the Owner's Representative.

- F. Coordination.
 - 1. Coordinate location, mounting height, and orientation of wiring devices with adjacent outlets for other systems such as HVAC control, voice/data, security, fire alarm, etc.
 - 2. Communications Outlets. Where 4-plex receptacles (i.e., double duplex) are indicated or shown on the Drawings in the vicinity of communications outlets for voice, data, and telephone systems provide standard 4-inch by 4-inch recessed wall box flush with finished wall for communications outlet. Space 4-plex receptacle and communications outlet 6 inches horizontally between outside edges of adjacent boxes.
 - 3. Casework and Millwork. Coordinate devices installed in casework and millwork with the location, finish, and mounting arrangement of the casework and millwork. Review applicable shop drawings and coordinate the installation with applicable Division.
 - 4. Refer to Section 26 05 37, Boxes, for additional requirements.
- G. Wiring. Devices must be completely wired and installed. Provide hot, neutral, ground, and other connections of appropriate voltage as required for proper device and luminaire function. Luminaires and lighting controls must be operating properly at final completion.

3.5 RECEPTACLES

- A. Location.
 - 1. Install convenience outlets in a suitable steel outlet box centered at the height of 18 inches above floor, 8 inches above counters or above the backsplash level, or as indicated on the Drawings. Do not install receptacles partially in the backsplash and partially in the wall. Coordinate location with equipment and architectural Drawings.
 - 2. Position the center of communications outlets (telephone, data, computer and TV) 18 inches above floor or 8 inches above countertops, unless otherwise noted or indicated. Do not install communications outlets partially in the backsplash and partially in the wall. Coordinate with communications (Voice/Data) supplier, architectural Drawings, shop drawings, and millwork.
 - 3. Install specific-use receptacles at heights shown on Drawings.
 - 4. Mount receptacles generally where indicated on Drawings. The Owner's Representative reserves the right to make reasonable changes in receptacle locations without change in the contract sum.
- B. Position.
 - 1. Install receptacles vertically with ground pole on bottom. Install receptacles horizontally, where field condition does not allow vertical installation, with ground pole on left.
 - 2. Where receptacles are located adjacent to wall switches or communication outlets, group devices and mount vertically, or as indicated on Drawings.
- C. Type and Grade.
 - 1. Provide industrial-grade receptacles unless otherwise noted or specified.
 - 2. Provide locking-type receptacles (i.e., Twist-Lock) in corridors or other special type receptacles where indicated on Drawings.
- D. Ground Fault Circuit Interrupter (GFCI). Provide GFCI-type receptacle for receptacles within 6-feet of a water source such as sinks. Connect branch circuit wiring to line-side terminals of GFCI receptacle. Feed through to non-GFCI receptacles is not permitted.

3.6 WALL SWITCHES

- A. Location.

1. Set wall switches in a suitable outlet box centered at the height of 48 inches from the floor, except as otherwise shown.
 2. Where shown near doors, install switches and dimmers not less than 2 inches and not more than 12 inches from door trim.
 3. Verify door swings before rough in and locate switch on the strike side of the door as finally hung. Where glass wall or glass partition is indicated or provided at strike side of door, install switch on adjacent wall and clear of door swing.
 4. Where wainscot or backsplash occurs at the 48 inches level, install device in the wall above the wainscot or backsplash or as near the 48 inch level as possible to provide the most pleasing appearance. In no case shall the switch be installed partially in the wainscot or backsplash and partially in the wall.
- B. Position. Install wall switches in a uniform position so the same direction of operation will open and close the circuits throughout the job, generally up or to the left for the ON position.

3.7 DEVICE PLATES

- A. Type. Provide device plates for each outlet of the type required for service and device involved. Plates shall be provided for telecom and A/V per those documents
- B. Ganged Devices. Mount ganged devices under a single, one-piece device plate.
- C. Workmanship. Install devices and device plates level, plumb, and parallel to adjacent surfaces or trim. Devices shall be flush with the finished trim cover plates. Device plates shall be tight to surfaces over which they are installed.
- D. Patching. Where cover plates do not completely conceal the rough openings for the devices, it shall be the responsibility of the Contractor to patch, paint, etc. around the opening to the satisfaction of the Owner's Representative.
- E. Engraving. Engrave plates with 1/8-inch-high black letters, if designated for engraving.
- F. Labels. Where switches controlling devices that are out of sight, or where three or more switches are gang mounted, provide plates with labels to identify items being controlled, or areas being lighted. Refer to Section 26 05 53 for Electrical Identification requirements.

END OF SECTION

SECTION 26 28 16

ENCLOSED SAFETY SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of enclosed safety switches. All switches shall be fused.

1.2 REFERENCE STANDARDS

- A. ANSI/UL 98 - Enclosed and Dead-Front Switches.
- B. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches.
- C. NFPA 70 - National Electrical Code (NEC).
- D. NFPA 70E - Standard for Electrical Safety in the Workplace.

1.3 RELATED WORK

- A. Section 26 00 00, Electrical General Provisions.
- B. Section 26 28 13, Fuses - 600 Volt and Below.
- C. Section 26 05 73, Overcurrent Protective Device Coordination Study.

1.4 SUBMITTALS

- A. Provide product data on each type and rating of switch.
 - 1. Ratings including voltage, and horsepower or continuous current.
 - 2. Dimensioned outline drawings.
 - 3. Conduit entry/exit locations.
 - 4. Cable terminal sizes.
 - 5. Wiring diagrams.
- B. Provide arc-flash calculations and associated incident energy levels. Refer to Section 26 05 73, Overcurrent Protective Device Coordination Study.

PART 2 - PRODUCTS

2.1 CHARACTERISTICS

- A. Voltage. Provide switches with a voltage rating of 250 volts d-c, 240 volts or 600 volts a-c, as required for the installed system voltage.
- B. Type. Provide switches conforming to NEMA KS 1 standard for Type HD (heavy duty).
- C. Contacts. Provide switches with quick-make, quick-break contacts.

- D. Poles. Unless otherwise shown, provide 3-pole, visible blade switches.

2.2 CONSTRUCTION

- A. Enclosure. Provide NEMA 1 enclosures for switches in indoor dry locations. Provide NEMA 3R enclosures for switches located outside the building conditioned envelope. Provide NEMA 4X stainless steel enclosures for switches located in corrosive environments, unless otherwise shown.
- B. Operating Handle. Provide a handle suitable for padlocking in the OFF position with as many as three padlocks of 5/16-inch diameter shank. Use a defeatable, front accessible, coin-proof door interlock to prevent opening the door when the switch is in the ON position and to prevent turning the switch ON when the door is open.
- C. Terminal Shield. Provide incoming line terminals with an insulated shield so that no live parts are exposed when the door is open.
- D. Neutral. Provide each switch with an isolated, fully rated neutral block. Make provisions for bonding the block to the enclosure.
- E. Ground. Provide each switch with a ground lug.
- F. Fuse Holders. Provide switches with rejection-type fuse holders which are suitable for use with fuses specified under Section 26 28 13, Fuses - 600 Volt and Below. All switches shall be fused.
- G. Nameplates. Provide metal nameplates, front cover mounted, which indicate the switch type, catalog number and horsepower rating (with both standard and time delay fuses).

2.3 LISTING

- A. UL 98 - Safety Standard for Enclosed Switches.

2.4 MANUFACTURER

- A. GE Company.
- B. Square D Company.
- C. Eaton/Cutler-Hammer.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products individually wrapped, on pallets or in factory-fabricated fiberboard type containers.
- B. Store products in a clean and dry space, elevated above grade, and protected from weather, sunlight, moisture, corrosion, dirt and damage.
- C. Handle products carefully to avoid damage to material components, enclosure and finish. Damaged products shall be rejected and not be installed on project.

3.2 INSTALLATION

- A. Install safety or disconnect switches where indicated, in accordance with the manufacturer's written instructions, and the applicable requirements of NEC. Install safety and disconnect switches in accordance with the directions of the Owner's Representative.
- B. In general, mount switches and disconnects so that operating handle is approximately 60 inches above finished floor. Where grouped, align tops of switches.
- C. For equipment with motors larger than 1/8 hp, provide disconnect switches within sight of the motor.
- D. Mount motor and circuit disconnect enclosures, independent of equipment served, on columns or freestanding on a bolted unistrut-type or galvanized welded angle iron framework anchored to floor. Refer to Section 26 05 29, Metal Framing and Supports.
- E. Switch interiors shall be maintained clean until final acceptance by Owner. Switch exteriors shall be maintained free of mud, spray-on insulation, paint spray and other substances not placed on the exterior surface by the switch manufacturer.

3.3 FUSIBLE DISCONNECT SWITCHES

- A. Provide fusible disconnect switches only. Coordinate with Divisions 14, 21, 22, 23, and equipment supplier for warranty and listing requirements of equipment approved by submittal.
- B. Install fuses in fusible disconnect switches. Provide permanent marking inside switch enclosure for fuse type and size.

END OF SECTION

SECTION 26 29 13

MOTOR STARTERS - 600 VOLT AND BELOW

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section specifies the furnishing and installation of individual motor starters rated 600 volts and below.

1.2 REFERENCE STANDARDS

- A. ANSI C19 - Industrial Control Apparatus.
- B. NEMA ICS - Industrial Controls and Systems.
- C. UL 508 - Industrial Control Equipment.

1.3 RELATED WORK

- A. Section 26 00 00, Electrical General Provisions.
- B. Section 26 28 13, Fuses - 600 Volt and Below.
- C. Section 26 35 33, Low Voltage Power Factor Correction.

1.4 SUBMITTALS

- A. Product Data. Provide product data, including the following:
 - 1. Ratings including voltage, and horsepower or continuous current.
 - 2. Dimensioned outline drawings.
 - 3. Conduit entry/exit locations.
 - 4. Cable terminal sizes.
 - 5. Wiring diagrams.
- B. Owner Manuals. Provide owner manuals per the requirements of Division One and Section 26 00 00.

PART 2 - PRODUCTS

2.1 MAGNETIC MOTOR STARTER

- A. Type. Provide 3-phase, magnetic, full-voltage, nonreversing combination fused switch motor starters.
- B. Overload Relays. Provide solid state 3-phase RMS-sensing ambient-compensated motor overload relay with phase loss and unbalance protection. Where specified under other Sections or specifically identified on Drawings, provide an ambient-compensated thermal overload relay in each phase leg, either bi-metallic or melting alloy type.
- C. Contactor. Size contactors according to NEMA standards or as shown, minimum size NEMA 1.

1. Provide main pole in each phase leg, the number and type of auxiliary contacts to perform the required functions, and two spare auxiliary contacts, one normally open and one normally closed.
 2. Use double break contacts of silver-cadmium oxide or similar material to minimize sticking or welding.
 3. Provide contactor coils suitable for continuous operation at 120 volts, 60 hertz.
- D. Control Power Transformer.
1. Voltage. Provide in each enclosure a single-phase control power transformer with a 480-volt primary and a 120-volt secondary. Provide 208-volt primary and 120-volt secondary where indicated on the Drawings.
 2. Fuses. Fuse both primary lines of the transformer and connect to Line 1 and Line 2. Fuse the secondary line leaving transformer terminal X1. Ground the line leaving terminal X2. Use rejection-type fuse clips and RK-1 type current limiting fuses on the primaries. Coordinate primary fuses with secondary fuse to clear a faulted transformer but not blow on magnetizing inrush current.
 3. Size. Provide manufacturer's standard size transformer unless noted otherwise on the Drawings.
- E. Enclosure. Provide NEMA 1 enclosures for starters in dry interior location, unless otherwise indicated on Drawings. Enclosures for starters located outside the building conditioned envelope shall be NEMA 3R. Enclosures for starters located in corrosive environments shall be NEMA 4X.
- F. Control Devices. Provide control devices on front panel of enclosure, as follows.
1. Selector Switches. 30mm, Heavy-duty, oil-tight, maintained contact, 3 position, with marked nameplate HAND-OFF-AUTOMATIC, unless otherwise indicated.
 2. Pushbuttons. 30mm, Heavy-duty, oil-tight, momentary contact with marked nameplate START-STOP, unless otherwise indicated.
 3. Indicating Lights. 30mm LED-type, heavy-duty, oil-tight transformer type with rated life of 20,000 hours, minimum. Neon and incandescent lamps are not acceptable. Provide red (running) and green (stopped) lenses. On two-speed starters, provide amber (low speed), red (high speed) and green (stopped) lenses.

2.2 COMBINATION SWITCH-STARTER

- A. Type. Provide combination fused disconnect switch and magnetic motor starter. Non-fused switches are not acceptable.
- B. Switch. Heavy-duty, quick-make and quick-break. Provide fused type only. Provide number of poles to match starter; 3-pole unless otherwise indicated. Make provisions for padlocking in the open position.
- C. Fuse Clips. Provide rejection-type fuse clips.
- D. Starter. Provide magnetic motor starter as specified in Article 2.1, this Section.
- E. Enclosure. Provide an enclosure of NEMA type as specified in paragraph 2.1E of this Section, unless otherwise indicated on Drawings.
- F. Fuses. Provide fuses conforming to Section 26 28 13, Fuses - 600 Volt. Furnish one spare set of fuses for each different type and size fuse installed.

2.3 MANUAL MOTOR STARTERS

- A. Provide line voltage manual motor starters for single-phase motors as indicated on the Drawings. Include bimetallic thermal overload protection in each ungrounded phase leg. Provide the toggle-operated starter in a NEMA 1 enclosure unless otherwise indicated.

2.4 MANUFACTURER

- A. Eaton/Cutler-Hammer.
- B. General Electric.
- C. Square D.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products individually wrapped, on pallets or in factory-fabricated fiberboard type containers.
- B. Store products in a clean and dry space, elevated above grade, and protected from weather, sunlight, dirt, moisture, and corrosion.
- C. Products shall not be used as work tables, scaffolds, or ladders.
- D. Handle products carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damaged products shall be rejected and not be installed on project.
- E. Refer to Part 3 of Section 26 00 00, Electrical General Provisions.

3.2 INSTALLATION

- A. Location. Install units where indicated on the Drawings. In general, mount combination units so that operating handle is approximately 60 inches above finished floor. Mount non-combination units so that control device is approximately 54 inches above finished floor. Where grouped, align tops of units.
- B. Supporting and Securing. Provide channels and framing for support of motor starters, as specified in Section 26 05 29, Mechanical Framing and Supports. Provide housekeeping pads for freestanding and floor-mounted units, as specified in Section 26 05 29 and Section 26 05 00, Electrical General Provisions.
- C. Arc-Flash. Include manufacturer's label indicating incident energy levels associated with calculated arc-flash event(s) for motor starter fault conditions.

3.3 RATINGS

- A. Where motor horsepower is at the upper limit of capacity for standard starter size, use next larger size starter.

3.4 OVERLOAD SETTINGS

- A. Field Setting. Set overload relays at maximum values permitted by NEC 430.32, based on actual installed motor nameplate full load amperes.
- B. Capacitors. Coordinate overload settings with NEC 460.9 requirements where power factor correction capacitors are provided.

3.5 SPARES

- A. Fuses. Provide one spare set of fuses for each size and type fuse used in the installed equipment. A "set" of fuses shall be one fuse for each phase leg installed.
- B. Refer to Section 26 28 13, Fuses – 600 Volt.

END OF SECTION

SECTION 26 32 12
GENERATOR LOAD BANK

PART 1 GENERAL

1.1 SCOPE OF WORK

- A. This specification contains the minimum requirements for the design, manufacture and testing of a UL listed, air-cooled, outdoor weatherproof resistive load bank.
- B. The load bank is required for periodic exercising and testing of the (standby) emergency power source. The load bank shall be permanently mounted in a weatherproof enclosure, forced air cooled with remotely mounted control panel.
- C. Should the vendor take exception to any part of this specification, it shall be stated in the bid, and referenced to the specification line number.

1.2 STANDARDS

- A. The equipment shall comply with the latest applicable provisions and latest recommendations of NEC, NEMA, and ANSI standards.
- B. The load bank shall be listed to UL Standard 508.

1.3 SUBMITTALS

- A. The Load Bank Submittals shall include applicable shop drawings (schematic drawings, outline drawings, technical description, and manufacturer's cut sheet) for each type and size of load bank required.
- B. Electrical schematic drawings shall be provided to detail the operation of the load bank and the provided safety circuits. Over-current protection and control devices shall be identified and their ratings marked. A system interconnection drawing shall be included for control wiring related to the load bank.

PART 2 PRODUCTS

2.1 APPROVED MANUFACTURER

- A. Load Banks Direct, LLC of Erlanger, KY, USA

2.2 LOAD BANK RATINGS AND DESIGN FEATURES

- A. The load bank shall be rated as shown on plans with 25 KW minimum load step resolution provided.
- B. The load bank shall be Forced Air-Cooled, rated for continuous operation with integrally mounted blower motors with high-performance, direct-driven fan blades to deliver the required airflow volume (CFM) for cooling resistor load elements.
- C. The load bank shall include an integral voltage control power transformer to deliver the necessary 120 Volt AC required for control circuit operation.

- D. The load bank shall include a (LOCAL or REMOTE) operator control panel including Emergency Stop (E-STOP) push button, Main Power On/Off switch, Blower Start/Stop push buttons, Fan-Phase Reversal switch (ABC-OFF-ACB), Master Load On/Off switch, and Individual Load Step switches (KW On/Off) provided for each load step. Illuminated indicators provided for Power On, Blower On, Motor Overload, Air-Flow Failure, Over-Temperature, and Load Dump.
- E. The load bank shall include a fully equipped, 3-phase Digital Metering System that measures a standard range of 16 load parameters including 3-phase, Volts, Amps, Frequency and Power Functions and includes RS485 communication (Modbus protocol) for remote reading - compatible with PC, PLC, and data loggers.
- F. The load bank shall include resistor load elements to provide the necessary KW load rating for each load step. Resistors are fully supported across their entire length within the air stream by stainless steel support rods which are insulated with heavy-duty, high-temperature ceramic insulators. Change in resistance is minimized by maintaining conservative resistor designs.
- G. The load bank shall include an automatic Load Level Controller. Load Level Control provides automatic load regulation by sensing the downstream connected load and adjusting the amount of supplemental load (load bank steps) applied. Automatic Load Level Controller adds and subtracts Load Bank load in response to dynamic power fluctuations in the connected facility load. It utilizes the Load Bank as a "supplemental load" for maintaining a minimum load on the power source.

2.3 LOAD BANK OPERATOR PROTECTION AND SAFETY FEATURES

- A. The load bank shall include a Control Power Emergency-Stop (E-STOP) push button to disable control power voltage to all operator control power circuits, including blower circuit and load application circuits.
- B. The load bank shall include visual detection and display of Main Power On, Blower Motor On, Motor Overload, Air-Flow Failure, Over-Temperature and Load Dump on the Operator Control Panel.
- C. The load bank shall include branch circuit fuse protection provides short-circuit fault protection of all load steps. Fuses shall be fast-acting, current-limiting type with an interrupting rating of 200K A.I.C.
- D. The load bank blower motors shall be short-circuit protected by current-limiting fuses and thermally protected by overload relays.
- E. The load bank shall include differential air pressure switch(es) to provide protection from loss of cooling air or insufficient airflow. The switch(es) will automatically remove all load if an airflow problem is detected and lock-out the load application controls.
- F. The load bank shall include over-temperature switch(es) to monitor load bank exhaust temperature. The switch(es) will automatically remove all load if an over-temperature condition is detected and lock-out the load application controls.
- G. The load bank shall include appropriate operator warning and cautionary statements, labels, or signage located visibly on the access panels.

2.4 LOAD BANK CONSTRUCTION

- A. The load bank enclosure shall be constructed of galvanized steel with powder coat paint finish with exterior stainless steel fasteners. Bolt on access panels shall provide a dead-front enclosure, safely enclosing all electrical and mechanical connections.
- B. The load bank shall be designed for installation and operation in an outdoor environment with sufficient fresh intake air available. The enclosure shall be designed for direct mounting to a customer supplied concrete pad.
- C. The load bank cooling airflow shall be drawn in from the screened air-intake sides, with hot air vertically exhausted from the top of the unit away from personnel. Low-profile, stainless steel exhaust air-gravity louvers shall be provided for superior all-weather protection.

PART 3 EXECUTION

3.1 GENERAL

- A. The load bank manufacturer shall have a formal written Quality Policies Manual outlining their quality management system. This manual shall be made available to the purchaser upon request.
- B. The load bank shall be provided with a detailed Instruction and Maintenance Manual outlining the proper operation, installation, environmental, safety precautions, and maintenance of the load bank. This manual shall be made available to the purchaser upon request.
- C. The load bank shall be fully tested by a trained factory technician prior to shipment. Each load step shall be calibrated and tested at rated voltage with voltage and current measurements recorded. Additional tests shall include resistance tolerance testing, applied potential (hi-pot) testing per IEEE standards, and verification of all safety circuits and operator control circuits. Blower circuit shall be tested at rated voltage for proper operation. Upon completion, load bank test data shall be made available to the purchaser upon request. After load bank is installed on site and connected to the existing generator, it shall be tested again at all load step levels up to the full load output. The full load output shall be tested for a minimum of 30 minutes. In addition, the load dump circuit shall be tested for proper operation. Provide a report to the Owner following the test.
- D. Install load bank on a 4" concrete pad. Install load bank per manufacturer's instructions.

END OF SECTION

SECTION 26 33 24

48V DC BATTERY SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of a station battery for a nominally rated 48 volts DC, a rack and battery-charging equipment and panelboard, all mounted inside a NEMA 1 metallic enclosure.

1.2 REFERENCE STANDARDS

- A. ANSI/IEEE 1375 – Protection of Stationary Battery Systems
- B. NFPA 70 – National Electrical Code (NEC)
- C. NFPA 110 – Emergency and Standby Power Systems
- D. UL 1564 Battery Charges, Industrial
- E. UL 1989 Standby Batteries

1.3 SUBMITTALS

- A. Submit product data on batteries, battery charger and accessories.
- B. Include outline and support point dimensions of enclosures and accessories; number of cells, unit weight and total weight; voltage, ratings and capacities. Capacity shall be based on requirements of the 5kV metal-clad circuit breakers switchgear in Section 26 13 00.
- C. Electrical Diagrams: Submit schematic and wiring diagrams of the electrical system showing all factory wiring and clearly indicating all wiring and connections to be made in the field.

PART 2 - PRODUCTS

2.1 BATTERY

- A. Type: Valve Regulated Lead Acid (VRLA) plate type, with short-period high-rate discharge capability for switchgear-control application. Provide absorbed glass-mat (AGM) or standard wet-cell battery. Gel-cell batteries or similar designs employing a gelled-electrolyte or electrolyte paste is not acceptable.

- B. Capacity: Amp-Hours at the 8-Hour discharge rate and amperes for 1 minute requirements shall be obtained from the 5kV metal switchgear manufacturer. Capacity shall consider and end voltage of not less than 1.14 volts per cell at 77 degrees F, starting from a fully charged cell.
- C. Voltage: 48 volts nominal.
- D. Containers: Translucent, impact-resistant polypropylene with minimum and maximum levels indicated.
- E. Number of cells: As required. Coordinate requirements with 5kV switchgear manufacturer.
- F. Caps: Flash arrestor's self-sealing removable type.
- G. Other Requirements: Provide batteries complete with all inner-cell and inter-rack connectors, end lugs and each battery filled with electrolyte, fully charged and with standard accessories.

2.2 RACK

- A. Provide a suitable steel rack to support the complete bank of batteries needed to support the metal clad switchgear line up. Finish metal so burrs, sharp edges and other similar imperfections are removed and surface is smooth. After fabrication, paint with alkaline paint, ANSI 61 Light Gray.

2.3 CHARGER

- A. Type: Full-wave solid state, with fully automatic AC voltage compensation, DC current limiting at not more than 140 percent of rated output current, suitable for battery supplied in paragraph 2.1 above.
- B. Rating:
 - 1. Input: 120 volts + 10 percent, 60 hertz + 5 percent, single phase.
 - 2. Output: 48 volts (nominal) and required amperes DC continuous, + 2 percent voltage regulation.
- C. Charging Voltage:
 - 1. Float Voltage – Adjustable 1.35 to 1.45 volts per cell.
 - 2. High-Rate Voltage – Adjustable 1.50 to 1.60 volts per cell.
- D. Accessories: Provide the following:
 - 1. Incoming circuit breaker.
 - 2. "AC Power ON" LED-type indicating light.
 - 3. AC surge suppressor.
 - 4. DC ammeter, + 2 percent accuracy.
 - 5. DC voltmeter, +2 percent accuracy.
 - 6. Float or high-rate voltage adjusting potentiometer.
 - 7. Manually operated 0 to 24 hour timer that will put charger on high-rate charge for selected time and automatically recharge to float charge when time out. Include "Float Charge" and "High Rate Charge" long-life LED type indicating lights.

8. Alarm relays for local monitoring and remote monitoring of the following parameters:
 - a. Low DC voltage
 - b. High DC voltage
 - c. No Current
 - d. Ground
 - e. Loss of AC power
 - f. These signals shall be connected to the building automation system (BAS).
9. Ground detector system, complete, indicating resistors, dual indicating lights, relays and wiring.
10. Output fuse.

2.4 ENCLOSURE:

- A. Provide a freestanding closure not wider than 48 inches or deeper than 36 inches to house the battery charger, relays, batteries, battery rack and branch circuit panelboard. Make enclosure ridge, with two front-opening doors, louvered to assure adequate ventilation of batteries to be mounted in lower part. Use full-length piano hinges on doors and cushioned, magnetic door holders for closed position. Install charger in top portion, with all meters and controls visible and directly accessible. Finish enclosure with alkaline paint ANSI No. 61 Light Gray.

PART 3 - EXECUTION

3.1 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Store batteries, charger and accessories in a clean and dry space and protect from the weather.
- B. Handle batteries, charger and accessories carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damage components, cells or other materials shall be rejected.

3.2 INSPECTION:

- A. Installer shall examine the areas and conditions under which batteries, charger and accessories are to be installed and notify the Contractor in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.3 INSTALLATION:

- A. Install station batteries, chargers and accessories as indicated, in accordance with the manufacturer's written instructions, the applicable requirements of the NEC, NEMA and ANSI and local and National Codes, Standards and regulations. Install in accordance with the directions of the Owner's Representative.

- B. Support: Provide proper support for installation of battery rack, in accordance with manufacturer's written instructions and directions of the Owner's Representative. Install enclosure where shown on plan. Interconnect all battery cells, fill and fully charge. Check and verify all alarm relays and interface with the BAS system.

END OF SECTION

SECTION 26 36 25

5kV EMERGENCY GENERATOR PARALLELING SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

- A. Custom designed 5kV emergency generator paralleling switchgear as specified herein and as shown on the drawings. One new 750kW natural gas generator and two existing 800kW natural gas generators will be connected to this switchgear. All three generators will be Cummins and will have the Power Command 3.3 controllers mounted at the gensets. In addition, one normal power 4.16KV utility feed will be connected to the new switchgear..

1.2 REFERENCE STANDARDS

- A. ANSI / IEEE C37.04 – Standard Rating Structure for AC Medium Voltage Circuit Breakers.
- B. ANSI C37.06 – AC Medium Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities.
- C. ANSI/ IEEE C37.09- Standard Design and Production Testing
- D. ANSI / IEEE C37.20.2 – Standard for Metal-Clad Switchgear.
- E. ANSI / IEEE C37.90 – Relays and Relay Systems associated with Electric Power Apparatus.
- F. ANSI C57.13 – Requirements for Instrument Transformers.
- G. ANSI / NFPA 70 – National Electrical Code.
- H. ANSI / NFPA 110 – Emergency and Standby Power Systems.
- I. IEEE 446 – Recommended Practice for Emergency and standby Power Systems for Commercial and Industrial Applications.
- J. NEMA SG-4 – Alternating Current Medium Voltage Circuit Breakers
- K. NEMA SG-5 – Power Switchgear Assemblies.
- L. U.L. – Applicable Standards.

1.3 QUALITY ASSURANCE

- A. The equipment is to be the product of a manufacturer who has produced this type of equipment for a minimum period of ten years. The manufacturer's facility shall be ISO 9001 certified.

1.4 SUBMITTALS

- A. Include the following for approval:

1. A detailed three line diagram of the entire lineup including all relays, meters, controls etc.
2. Outline drawings showing plan and elevation views of each piece of equipment, and containing the following information for each item:
 - a. Size.
 - b. Weight.
 - c. Dimensions and weight of the equipment shipping splits.
 - d. Typical conduit entry areas
 - e. Equipment door detail drawings showing all meter annunciator and control device locations with nameplate legends.
 - f. Base plans for the location of the equipment floor channels, anchor bolts and conduit entrance spaces.
 - g. Catalog Cut sheets for all circuit breakers and protective devices.
 - h. Short-circuit rating of bus, and interrupting and withstand ratings of breakers.
 - i. Detailed bill of material indicating items to be released first, due to long lead-time.
 - j. System delivery schedule.
 - k. Proposed sequence of operation for entire system.
 - l. Make and manufacturer of all major components of the switchgear and control lineups.

1.5 FACTORY TESTING

- A. Factory test the 5kV emergency generator paralleling switchgear to simulate a complete and integrated system. Install the circuit breakers in their actual position and electrically and mechanically test. Include protective relay testing for each circuit breaker. The intent of the relay test is to confirm the relay output contact trips the breaker as required. A coordination study will not be completed prior to this test. Submit a narrative of the system operation that was utilized when testing the equipment. Submit copies of the test reports to the Engineer.
- B. Perform the following separate tests on the power switchgear:
 1. Dielectric.
 2. Mechanical.
 3. Grounding of instrument transformer case.
 4. Electrical operation and control wiring.
 5. Control wiring insulation.
 6. Polarity.
 7. Sequence.

1.6 SERVICE AND WARRANTY

- A. Manufacturer shall have an established network of service centers capable of servicing the specified equipment.
- B. Service center and manufacturer's personnel shall be on call 24 hours a day, 365 days a year. Factory train and certify personnel in the maintenance and repair of the equipment.
- C. Warrant the equipment to be free from defects in material and workmanship for 2 years from the date of start-up.

1.7 CERTIFICATION

- A. To certify compliance with the specification, submit a copy of this specification, annotated to show compliance, deviation or proposed alternate by each paragraph. Fully explain any deviations or proposed alternates.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Russelectric Inc.
- B. Automatic Switch Company (ASCO).
- C. The equipment must meet the requirements for the 5kV emergency generator paralleling switchgear described in this section and shown on the drawings. Deviations or alternates to this specification will only be considered if a complete written description of the proposed changes is provided with submittals for approval. Any variances not specifically enumerated prior to bidding shall be considered non-responsive. Contractor shall modify the building and/or interfacing equipment, which are affected as a result of the proposed changes at no increase in cost to the Owner. If the equipment does not fit in the space shown on the plans with the required NEC and maintenance clearances, the switchgear will not be accepted.

2.2 DESCRIPTION

- A. Provide indoor metal-clad switchgear consisting of a lineup of 4.16 kV, 250 MVA class draw-out circuit breaker cubicles, as shown on the drawings. Also provide a master control cubicle equipped to monitor and control the operation of the entire emergency generator system. The Master control cubicle and the three generator control cubicles shall be located remote from the switchgear in a separate room.

2.3 STATIONARY STRUCTURE

- A. Provide a switchgear stationary structure consisting of a NEMA 1 rigid, freestanding, bolted assembly of individually enclosed breaker units and auxiliary units. Make each unit of the same depth. Fabricate the units from structural members and smooth, flat, leveled steel plates. Provide ample strength in the assembly to support the equipment mounted inside, properly withstand handling and shipment and maintain proper alignment. The switchgear arrangement must match the plans and elevations shown on the drawings
- B. Doors. Provide hinged doors for access to each breaker compartment and to any other compartment requiring routine inspection or maintenance. Hinge and structurally reinforce doors to resist short circuit stresses, and so as not to warp, sag or bind. This is not intended to require arc resistant switchgear. Make doors open not less than 90 degrees, to permit breaker removal without interference with door-mounted devices and with hand-release stop to prevent further opening or closing.
- C. Steel Panels. Secure instrument and control panels to the main structure with hinges and suitable latches in order to maintain alignment and provide adequate support. Make provisions to adequately secure all wiring to and from the panels, yet allow sufficient flexibility to prevent fatigue and eventual breaking of conductors. Provide removable bolted panels for rear of units. Provide sides of end unit with removable bolted panels to facilitate the addition of future units.

- D. Component Isolation. Construct and arrange the stationary structure so that breakers, main buses, instrument transformers, cable termination areas and controls are completely isolated from each other within the same unit by means of removable steel barriers, and that each unit is isolated from adjoining units.
- E. Breaker Compartments. Mount each breaker in an individual compartment formed of leveled steel plates with necessary framed steel members and aligning tracks as required to provide positive alignment of primary and secondary disconnect devices. Provide the compartment with openings of the required dimensions to permit the passage of primary movable disconnecting contacts of the breaker from the connected to the test/disconnected position. Cover the openings with shutters when the breaker is in the test/disconnected position so that no parts connected to the bus side are exposed. Make shutters operate automatically, opening just prior to being reached by the primary movable disconnecting contacts when moving the breaker from the test/disconnected position to the connected position, and closing just after the primary movable disconnecting contacts have passed when moving the breaker from the connected position to the test/disconnected position. Use a steel barrier to separate stationary primary contacts on bus side from stationary primary contacts on load side. Construct primary and secondary disconnecting contacts of silver-plated copper. Make depth of units sufficient to allow moving breaker from the connected to the test/disconnected position with the front door closed. Shutters and barriers shall be grounded.
- F. Lifting Provisions. Provide lifting hooks on top of each shipping section.
- G. Finish. Grind steel surfaces smooth after fabrication. Then chemically clean and treat the steel surfaces and apply rust-preventive primer paint or powder coat finish. After priming, thoroughly paint the inside and outside with ANSI 61 gray finish. Provide 1 quart of finish paint for touch-up after field installation.

2.4 CIRCUIT BREAKERS

- A. Type and Manufacturer. Provide horizontal draw-out type vacuum circuit breakers designed for use in metal-clad switchgear. Acceptable manufacturers are Eaton/Cutler-Hammer, General Electric and Square D. Make breakers of same current rating completely interchangeable.
- B. Current Rating. Provide 1200A breakers identical in all respects.
- C. Interrupting Rating. Provide breakers rated for 5kV, 60 hertz voltage class and 250 MVA withstand class having a minimum rated short circuit current of 29 kA, a rated maximum symmetrical interrupting capability and 3-second short time current carrying capability of 36 kA, and a closing and latching capability of 58 kA. Total fault clearing time to be less than 5 cycles.
- D. Insulation Level. Rate breakers suitable to withstand the ANSI standard 19 kV low frequency test and 60 kV impulse test.
- E. Contacts. Make primary, main and secondary contacts of silver-plated copper.
- F. Arc Interruption. Arc to be extinguished in a sealed vacuum bottle with minimum current chopping.

- G. Operators. Provide breakers operated by mechanically and electrically trip-free, d-c, motor-charged-spring, stored-energy mechanisms. Additionally, provide a manual means of charging the mechanism.
- H. Close and Trip. Provide a d-c closing coil and a d-c shunt trip coil on each breaker.
- I. Circuit Breaker Removal. Provide a mechanism for moving the breaker from the connected to the test/disconnected position and for removal from the cubicle. Mechanically interlock the operating mechanism so that the breaker cannot be inserted or removed if closed and an additional interlock that trips the breaker and automatically discharges the stored-energy operating springs when breaker is removed from the cubicle.
- J. Breaker Mechanism Operated Contacts. Provide each breaker with six auxiliary contacts (3a, 3b) operated by the MOC auxiliary switch to indicate same status as the breaker mounted auxiliary switch.
- K. Primary Insulating Bushings. Provide cycloaliphatic or glass polyester bushings to support primary stationary disconnect contacts.
- L. Breaker Mechanism Operated Auxiliary Switch. Provide each breaker with a breaker-operated auxiliary switch having not less than three auxiliary contacts (1a, 2b) for external use rated 10 amperes at 48 volts.

2.5 MAIN BUS

- A. Rating. Rate the main bus not less than 1200A, based on continuous duty, including skin and proximity effect, insulation, steel enclosure, and a 65 C maximum temperature rise with an outside ambient temperature of 40 C.
- B. Bracing. Brace bus components to amply resist forces due to short circuit currents equal to those specified for the circuit breakers.
- C. Material. Make buses of 98 percent IACS conductivity copper bars with rounded edges. The bars shall be silver-plated at all connections and of a bolted design using silicon bronze bolts.
- D. Insulation. Insulate buses with epoxy-coated, track-resistant, flame-retardant material applied by fluidized bed process over the entire length. Design insulation for 5kV service, able to withstand the same ANSI low frequency and impulse tests specified for the breakers. Provide insulation having a high-resistance conducting surface in contact with the bus to eliminate corona damage to the bus insulation.
- E. Supports. Track-resistant glass polyester.
- F. Connections. Make connections to the bus with silicon bronze bolts with lock washers. Silver-plate the bars at current carrying connections. Use molded removable covers or similar devices at connections to the bus. Provide for future extension of main bus at the end of switchgear.

2.6 GROUND BUS

- A. Provide an un-insulated ground bus of 98 percent IACS conductivity copper. Attach bus to the stationary structure and brace same as main bus. Ground equipment by connection to this ground bus. The terminations shall be of a compression connector type. Make

provisions inside the switchgear for the attachment of a No. 4/0 AWG bare stranded copper cable for external connection to a grounding electrode conductor. Provide for future extension of ground bus at the end of switchgear. Silver-plate joints at connections and use silicon bronze bolts.

2.7 ENTRANCES

- A. Make provisions for entrance of conductors in conduit to the top of each circuit breaker section. Bottom entry not required. Provide ample space for 5 kV stress cone termination. Provide crimp compression-type two-hole terminals for power and ground copper cables.

2.8 INSTRUMENT TRANSFORMERS

- A. Factory Installation. Install and test at the factory instrument transformers with ratings as specified and shown.
- B. Voltage Transformers. Design voltage transformers to fit into and coordinate with the complete switchgear units, including the instruments, relays, meters and devices specified. Rate transformers not less than 150 volt-amperes on an accuracy basis and 500 volt-amperes on a thermal basis. Provide transformers designed to withstand a secondary short circuit for at least 1 second with voltage rating at 60 hertz as shown. Provide transformers with not less than an ANSI standard accuracy classification adequate for the burden connected. Install transformers on a suitably designed draw-out carriage with primary and secondary disconnect devices and a grounding device. Furnish primary fuses of the current limiting type in each phase. Coordinate fuses to clear a faulted transformer, but not to blow on magnetizing inrush current or on a short-circuited secondary, except as backup to secondary fuses. Provide secondary fuses on ungrounded secondary lines, properly coordinated with the primary fuses. Provide suitable disconnecting means in each unit that requires voltage transformer secondary lines. Locate the generator voltage transformers at the top of each generator breaker cubicle.
- C. Current Transformers. Design the instrument current transformers for installation on bushings of stationary primary disconnecting contacts in circuit breaker cubicles. Provide space for one current transformers per bushing. Coordinate the thermal, mechanical, and insulation limits of the current transformers with that of the breakers and bus of the switchgear in which they are to be installed. Provide transformers with accuracy suitable for the meters and relays specified. Provide shorting block and surge protection for each current transformer.
- D. Connections. Make connections from the current transformers such that the transformers may be removed and changed without damage to the connections or leads.

2.9 PROTECTIVE RELAYS

- A. Type. Provide utility grade, semi-flush mounted General Electric (Multilin) SR489 Generator Management Relay for each generator breaker and General Electric (Multilin) SR-350 relay for each feeder breaker and normal/utility breaker. Provide Bacnet protocol for communication with the building DDC system. If Modbus is typical protocol, provide a converter for Bacnet. See paragraph 2.16 and drawings for ANSI protective relay device functions. Provide an additional SR-350 relay for three feeder breakers. These additional

relays will connect to current transformers located at the 480V side of the substation transformers.

2.10 CONTROL CONDUCTORS

- A. Provide 600 volt, minimum 90 C, switchboard type, stranded copper control conductors of minimum sizes No. 14 & 18. Use solderless compression pre-insulated type terminations. Provide ring-tongue type terminations for CT wiring and cage clamp type terminations for other control wiring. Number conductors on both ends with tubular heat-shrinkable PVC markers applied prior to the terminals being applied and with the number visible. Ink stamping is also acceptable. Separate low level signal circuits and provide with wire shields to minimize electromagnetic cross-talk and interference. Ground wire shields at the device only.
- B. Provide wire trough between each of the vertical sections to allow control wiring to pass through. Wiring shall not be spliced and shall be free of abrasions and tool marks. Neatly lace up or tie-wrap and harness wires, and support to prevent sagging or breakage from weight or vibration. Install wiring bundles in covered metal or plastic wire gutters.
- C. Run conductors to hinged doors through door terminal plug connections. Provide terminal blocks for all external connections in an accessible area not exposed to hazardous bus or cables.

2.11 NAMEPLATES

- A. Main Nameplate. Provide switchgear with a stainless steel main nameplate, prominently displayed on the front, indicating manufacturer's name, address and shop order number, year manufactured, and the following ratings:
 - 1. Nominal, maximum design and BIL voltage rating.
 - 2. Main bus continuous current rating.
 - 3. Interrupting, momentary and fault closing 3-phase symmetrical short circuit current rating.
- B. Provide engraved laminated plastic nameplates having white letters on red background to identify major components, vertical sections and breakers. Provide nameplates with letters 3/16 inch high. Attach nameplates with stainless steel screws.
- C. Caution Signs. Provide caution signs in accordance with the NEC and OSHA requirements.

2.12 POWER MONITORING DEVICES

- A. Type. Switchboard semi-flush type solid-state multi-meter instrument. Five-digit display, Eaton/Cutler-Hammer Power Expert, or accepted substitution. Install one unit on each circuit breaker cubicle and one on the master control section.
 - 1. Functions. As a minimum, the following functions shall be metered:
 - a. Phase volts.
 - b. Phase amperes.
 - c. kW with maximum demand.
 - d. kW/phase.
 - e. kVA/phase.
 - f. kVAR/phase.
 - g. kWh.
 - h. kVAh.

- i. kVARh.
- j. Power factor.
- k. kVA with maximum demand.
- l. Frequency.
- m. Individual harmonics.
- n. Total harmonic distortion.
2. Accuracy (Minimum Requirements).
 - a. Current and voltages: +0.20%
 - b. Frequency, power, demand and energy: +0.40%.
 - c. Power factor: +1.0%. Accuracy shall be maintained from 3-300%, and -0.5 to 1.00 to +0.5 for power factor.
3. Special Requirements. The meter shall be able to perform waveform capture and communicate directly with other multi-function meters and devices RS485 and Bacnet protocol. It shall have two 4-20ma programmable outputs as a minimum. All devices shall be networked together with wiring terminated at a terminal block.
4. Provide dry contacts wired to terminal blocks in the circuit breaker cubicle for the power monitoring devices to monitor the status of the following conditions:
 - a. Circuit breaker status (mechanism-operated cell switch): circuit breaker open, circuit breaker closed. Connect to DDC System.
 - b. Circuit breaker alarm: circuit breaker tripped on automatic trip function (i.e.: fault).
 - c. Coordinate with the DDC contractor for communication of electrical meters and circuit breaker alarm and status.

2.13 CONTROL COMPONENTS

- A. Electromagnetic Control Relays. Electromagnetic control relays to be suitable and adequately rated for their intended service. Relays in low-voltage low-current DC control circuits to have gold flashed contacts to ensure positive contact make. Relays for other than logic and dry contact switching to have contact ratings suitable to make and carry their required current at operating voltage.
- B. Instrument and Control Switches. Instrument and control switches to be rotary type with contacts totally enclosed. Handles to be of distinctive shapes to indicate their functions. Switch shall be supplied with titled escutcheon plate, suitably marked for each position. Switch to have positive means of maintaining contact with silver to silver wiping action. Circuit breaker control switch to be momentary-contact, spring-return to center with pistol-grip handle and target to indicate the previous operation of the switch. Manufacturer: Electroswitch Series 24, or accepted substitution.
- C. Indicating Lights. Lights to be heavy-duty type, 30.5 mm, LED, Red (close) and Green (open).
- D. Switchgear Control Power. Provide 24 DC control buses. Including in the master control section. Provide fused taps at each cubicle for circuit breaker spring charging motor, close and trip circuits and control power for power monitoring devices, as applicable. A 48VDC station battery system will be provided per specification section 26 33 24. Switchgear manufacturer is responsible for converting to 24VDV.
- E. Paralleling System Control Power. Provide a solid-state no break "best battery" system using the 24VDC generator starting batteries and 48 VDC station batteries. The system components shall be operational with voltages as low as 19 VDC. A 48VDC station battery system will be provided. Switchgear manufacturer is responsible for converting to 24VDV. All

control power shall originate at the 48VDC system. The generator batteries shall be used only as a backup to the station batteries.

2.14 ACCESSORIES

- A. Provide one set of standard accessories for testing and maintenance of the switchgear, including, but not limited to, one each of the following:
1. Manual stored-energy spring-charging handle.
 2. Hand crank for moving breaker between test and connected positions.
 3. Device for lifting and conveying of circuit breakers.
 4. Test cabinet for electrically testing breaker outside of housing.
 5. Set of test plugs for protective relays when applicable.
 6. Motorized, 120-volt, portable remote breaker racking unit with a 30-foot long cord for manually racking, one breaker at a time. The system shall automatically disconnect the racking motor power supply after the breaker is completely engaged (or disengaged) without damage to the motor or other equipment. Alternatively, a "spin-free" at both ends of the travel with a protective mechanism to avoid damage to the motor and other equipment is also acceptable.

2.15 PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

- A. System Programmable Controllers:
1. The "system" shall be controlled by redundant PLCs located in the master control cubicle. In the event the primary PLC fails, the system operation is to be backed up by an online PLC, to allow engine-generator units to start and parallel to the paralleling switchgear bus. Redundant (I/O) buses shall be provided, one for each PLC.
 2. The emergency generator paralleling switchgear manufacturer shall program the PLCs for system operation.
 3. The following is to be provided for the "system" programmable control system:
 - a. General Electric RX3I programmable logic controller or approved equal, with power supply, chassis, and input/output cards as required for system control.
 - b. A programmable controller, password protected operator interface panel is to be provided on the master control cubicle door. This panel is to allow the operator access to the PLC control without having to implement software changes. The panel can be used to change all timer settings, load demand and load control set-points, and load demand engine sequence positions. Hand held PLC programmers and/or laptop computers to make timer settings are not acceptable.
 - c. Incorporate a digital readout, solid state sequence display system such as an LCD screen on the operator interface panel to indicate the load demand engine starting and stopping sequence for four generators. If an engine is locked out, a lockout alarm indicator is to flash for the respective generator.
 - d. Provide a communication card in the GE PLC to allow for connection to Owner's energy management system. Communication card shall allow for communication via Bacnet.
 - e. The programmable controller shall allow only predetermined loads to be closed to the system bus, until additional engine generators are paralleled to the main emergency switchgear bus.
 - f. Configure the PLCs such that on failure of the primary PLC, the backup PLC instantly assumes system control at the current sequence step of the failed PLC, such that the system operational sequence (e.g., priority load control,

- load shed, load demand control, etc.) is completed without the need to restart the sequence.
- g. On failure of normal (utility) power, if both system programmable controllers fail, the control system is to be backed up with hardwired controls and interlocks to manually start each engine-generator unit and manually parallel to the bus; supplying load blocks designated as priority one.
4. Engine Generator Network I/O Drop:
- a. The engine starting is to be controlled by the system through distributed I/O to the master PLCs. Provide a Network interface module for each engine generator located in the respective generator control cubicle.
 - b. Provide programmable timer access, via the operator interface panel, for each engine generator to allow for the following field adjustable time settings:
 - 1) Fail to synchronize (30 to 240 seconds).
 - 2) Cool-down time (5 to 40 minutes).
 - 3) Crank attempts (1 to 8 attempts).
 - 4) Crank duration (5 to 40 seconds).
 - 5) Rest duration (5 to 40 seconds).
 - 6) Oil pressure build-up time (2 to 16 seconds).
 - 7) Spare #1 (User defined).
 - 8) Spare #2 (User defined).
 - c. Coordinate engine controls with Emergency Gas Engine Generator manufacturer Cummins. Refer to Section 26 36 26 under generator project.

2.16 ENGINE GENERATOR CONTROL AND POWER CUBICLES

- A. Provide a power cubicle and a control cubicle for each generator set. The power cubicle will be part of the 5KV paralleling switchgear lineup. The control cubicle will be remote from the power cubicle in a separate room and will be part of the control cubicle lineup consisting of the three generator control cubicles and the master controller cubicle. The power cubicle shall contain the circuit breaker, instrument transformers and protective relays. The remote control cubicle shall contain instruments and meters, control and instrument switches, indicating lights, network interface module, automatic synchronizer, power monitoring device, alarm and status indication and auxiliary devices associated with engine generator set control. The new generator and the two existing generators will have Cummins Power Command 3.3 Controllers located at the gensets. The Cummins controllers will be responsible for synchronizing the generators and closing them to the 5Kv PSE bus by controlling the generator breakers. The PSE master controller will provide a system overview and control load add/shed feeder breakers. Individual governor, voltage controller and automatic synchronizer mounted in the switchgear are not required since these functions will be assumed by the PCC 3.3 controllers.
- B. The following items are to be included in the Generator Power Switchgear Cubicles. This is typical for existing generators 1 and 2 and new generator 3.
 - 1. Circuit Breaker. Refer to paragraph 2.4 of this Section. References in this Section to generator power circuit breaker(s) means such breakers(s) located in this Emergency Generator Paralleling Switchgear.
 - 2. Protective Relay. Provide generator protective relay per Paragraph 2.9 of this Section with the following minimum functions as described and noted by ANSI device number:
 - a. ANSI 12 Over-speed (Alarm)
 - b. ANSI 27*Under-voltage
 - c. ANSI 32 Reverse Power
 - d. ANSI 49 Stator Over-temperature (Alarm)

- e. ANSI 51V Voltage Restrained Phase Over-current
 - f. ANSI 81*Under-frequency
 - g. ANSI 87G Generator Differential
 - h. ANSI 50 Instantaneous Over-current
- * Provide an adjustable time delay (0.1 to 6.0 seconds) on dropout.
- 3. Digital multimeter similar to Eaton Power Expert or equal.
 - 4. Set of two potential transformers, draw out type with 120V secondary.
 - 5. Set of three current transformers for metering, relaying etc.
 - 6. Lockout relay, Device 86, Electros witch LOR.
 - 7. Set of 3 phase, 1200A, insulated copper bus and ground bus. All joints to be silver plated.
 - 8. Set of control wiring, alarmed dc control voltage circuit breakers, terminals, nameplates etc. All wiring to be labeled at both ends. Wiring labels to match manufacturers drawings.
 - 9. Set of crimp type compression lugs for generator incoming conductors.
 - 10. Indicating Lights. Refer to paragraph 2.13 this Section. For each generator breaker provide a Red (Close) and Green (Open) pilot light.
- C. The following items are to be included in the Generator Control Cubicles with the exception of the Engine Governor controller and Automatic Synchronizer which will be located in the PCC 3.3 controllers. These two items are listed below for reference only. This is typical for generators 1, 2 and 3. All three generators will have the PCC3.3 controller. See E016 for additional information.
- 1. Engine Governor Control, Generator Voltage Control and Miscellaneous Engine Generator Set Controls: The Controls may include but are not limited to the following:
 - a. UL-listed electronic control portion of governor with load sharing.
 - b. Voltage regulator.
 - c. Voltage and speed adjust potentiometers.
 - d. Cross-current compensation transformer.
 - e. Isolation transformers when required.
 - 2. Automatic Synchronizer. ANSI Device 15 for engine generator units with or without solid-state comprehensive controller.
 - a. Provide an automatic solid-state active synchronizer to synchronize the respective incoming engine generator set with the paralleling bus. Synchronizer to be Woodward SPM-D, or acceptable substitution.
 - b. The synchronizer outputs are as follows:
 - 1) Bipolar DC signal suitable for driving the engine-generator governor/amplifier system and voltage regulator system.
 - 2) Sync contact closure to close the selected generator power circuit breaker when the generator voltage has the same amplitude, frequency and phase as the emergency generator paralleling switchgear bus.
 - c. The synchronizer controls are to include the following:
 - 1) Phase offset control.
 - 2) Gain control.
 - 3) Stability control.
 - d. The synchronizer is to become operative when the generator voltage source reaches approximately 75% of nominal. It is to assume control to rapidly match the frequency and phase of the engine generator with that of the generator paralleling switchgear bus, and close the selected generator circuit breaker with a minimum of system disturbance. Power circuit breaker closure outside the preset limits are not to occur.

- e. Within approximately 1 second after the generator circuit breaker closure, the synchronizer is to automatically relinquish control over the electronic governor and go into an idle mode.
 - f. The synchronizer is to operate indefinitely over an input voltage range of 80% to 125% of nominal, and over an ambient temperature range of -45 degrees to +70 degrees Celsius. The synchronizer is to be capable of meeting the dielectric and surges withstand capabilities, as set forth in IEEE Standard 472-1974/ANSI C37.90a-1974.
 - g. To ensure optimum compatibility with the governor control, provide automatic synchronizer compatible with the governor control system. Refer to Emergency Diesel Engine Generators, Section 26 36 26 under generator project.
 - h. The operational parameters described above also apply to the synchronizing functions when provided by the engine-generators with comprehensive solid state digital controllers.
3. Failure to Synchronize Reset. Provide means to reset the "Fail to Synchronize" alarm.
- a. Separate backlit LED annunciator with engraved windows for the following circuit breaker status indications:
 - 1) Circuit breaker open
 - 2) Circuit breaker closed
 - 3) Circuit breaker drawn out
4. Multiple Circuit Interlock. Provide a solid-state discriminator circuit for first-up, first-on operation of the generator set. This circuit shall positively prevent more than one set from being simultaneously connected to a dead bus. Upon initiation of the connection of the first set to the bus, the operator, at his discretion, shall be able to shift control of the remaining sets from automatic to manual synchronizing.
5. Engine Generator Selector Switch:
- a. Provide an engine selector switch appropriately labeled on each engine generator control panel cubicle door with the following minimum positions:
 - 1) Stop/Reset. The engine generator shall be locked out. Whenever the selector switch is placed in the "Stop/Reset" position while the engine generator is operating, the engine control system will immediately shut down the engine generator and trip the associated generator circuit breaker.
 - 2) Off. Provided to allow a normal shutdown, with a time delay to allow the engine to cool after operating under load. Whenever the engine selector switch is placed in the "Off" position while the engine is operating, the generator circuit breaker will trip, and the engine will continue to operate until the expiration of time delay setting of the idle relay (cool-down period).
 - 3) Auto. The engine generator shall be on standby and shall start whenever an engine start signal is received from the automatic transfer system. When normal (utility) power returns, and the transfer system signals the engine generator to shut down, the generator circuit breaker will be tripped, and the engine will continue to operate for the cool-down period.
 - 4) Run. Provide for manual initiation of engine-generator operation. When the engine selector switch is placed in the "Run" position, the engine will start and come up to speed. It will continue to run until the selector switch is returned to the "Off" or to the "Lockout/Reset" position. This position is provided for use in testing or for manual operation of the engine generator.

6. Alarm and Status Indication:
 a. Provide visual and audible indication of alarms and status at the operator interface, on the master control section to include readout and annunciation of the generator alarms as follows:

<u>Function</u>	<u>Mode</u>	<u>Color</u>
Low Lube Oil Pressure	Pre-alarm	Amber
Low Lube Oil Pressure	Shutdown	Red
High Engine Temperature	Pre-alarm	Amber
High Engine Temperature	Shutdown	Red
Low Coolant Temperature	Alarm	Red
Over-crank (Fail to Start)	Shutdown	Red
Over-speed	Shutdown	Red
Circuit Breaker Trip	Shutdown	Red
Reverse Power	Shutdown	Red
Fail to Synchronize	Pre-alarm	Red
Switchgear Controls Not in Auto	Flashing	Red
Generator HOA Switch Not in Auto	Flashing	Red
Engine Running	Status	White
Circuit Breaker Closed Failure	Alarm	Red
Control Voltage Failure	Alarm	Red
Engine Controller Failure	Alarm	Red
Auto Start	Status	White
Bus Under-frequency	Alarm	Red
Generator Lockout	Alarm	Red
Low Coolant Level	Alarm	Red
High Battery Voltage	Alarm	Red
Low Battery Voltage	Alarm	Red
Battery Charger AC Failure	Alarm	Red

- b. Provide the following indications with LED lamps on each generator control section: Engine alarm, Control voltage failure, Engine not available, Engine running, Engine shutdown, Breaker failure and Spare.
- c. Visual alarms are to be re-settable only after the fault condition has been corrected. The audible alarm is to include a silencing circuit with dedicated pushbutton, which after activation will permit audible annunciation of subsequent failures.
- d. A separate Lamp test pushbutton is to be a provided feature of all door-mounted visual indicators. Visual indicators are to have a minimum 1 square inch illuminated area.
- e. Provide drawings showing the interconnection wiring from this switchgear to the appropriate terminal blocks at the respective generator sets. Coordinate with Emergency Diesel Engine Generators, Section 26 36 26, for interconnections of power, controls and communications between engine-generator unit and the emergency paralleling switchgear.
- f. Provide elapsed time meter for generator running hours.
- g. Engine Starting Control Logic:
1. General:
 a. The engine starting control logic shall be PLC-based and shall automatically start, protect and monitor each engine generator set. The engine starting control logic shall be capable of controlling engines furnished with the following:
 1) Starting motor magnetic switch or relay.

- 2) Electrically operated fuel control/solenoid valve.
 - 3) Normally open contacts on protective devices that close for abnormal conditions of pressure, temperature, speed and liquid level.
- b. The engine starting control logic shall provide electrically isolated contacts for electronic governor control, electric fuel control, battery charger disconnect during cranking, and common shutdown alarm annunciation. Coordinate engine starting control logic with Emergency Diesel Engine Generators.

2.17 NORMAL/UTILITY CIRCUIT BREAKER CUBICLE

- A. Provide power and control cubicles in the same vertical section for the normal power feeder. The vertical section is to contain circuit breakers, instrument transformers, protective relays and power monitoring devices.
- B. Circuit Breaker. Refer to paragraph 2.4 of this Section. References in this Section to normal/utility power circuit breaker means such breakers located in this Emergency Generator Paralleling Switchgear.
- C. Protective Relay. Provide protective relay per Paragraph 2.9 of this Section with the following minimum functions as described and noted by ANSI device number:
 1. ANSI 50/51 Phase Instantaneous/Timed Over-current
 2. ANSI 50G/51G Ground Instantaneous/Timed Over-current
- D. Digital multimeter similar to Eaton Power Expert or equal.
- E. Set of two potential transformers, draw out type with 120V secondary.
- F. Set of three current transformers for metering, relaying etc. Locate on bus side bushings.
- G. One Zero sequence CT for relaying.
- H. Separate backlit LED annunciator with engraved windows for the following circuit breaker status indications:
 1. Circuit breaker open
 2. Circuit breaker closed
 3. Circuit breaker drawn out
- I. Lockout relay, Device 86, Electros witch LOR.
- J. Circuit Breaker control switch
- K. Set of 3 phase, 1200A, insulated copper bus and ground bus. All joints to be silver plated.
- L. Set of control wiring, alarmed dc control voltage circuit breakers, terminals, nameplates etc. All wiring to be labeled at both ends. Wiring labels to match manufacturers drawings.
- M. Set of crimp type compression lugs for normal power incoming conductors.

2.18 DISTRIBUTION FEEDER CIRCUIT BREAKER CUBICLES

- A. Provide power and control cubicles in the same vertical section for two each distribution feeder. See plans for quantity. Each vertical section is to contain circuit breakers, instrument transformers, protective relays and power monitoring devices.
- B. Circuit Breaker. Refer to paragraph 2.4 of this Section. References in this Section to normal/utility power circuit breaker means such breakers located in this Emergency Generator Paralleling Switchgear.
- C. Protective Relay. Provide protective relay per Paragraph 2.9 of this Section with the following minimum functions as described and noted by ANSI device number:
 - 1. ANSI 50/51 Phase Instantaneous/Timed Over-current
 - 2. ANSI 50G/51G Ground Instantaneous/Timed Over-current

Provide an additional protective relay utilizing only the 50/51 function for three of the feeder breakers per plans.
- D. Digital multimeter similar to Eaton Power Expert or equal.
- E. Set of two Bus potential transformers, draw out type with 120V secondary. Provide only one set, See E016.
- F. Set of three current transformers for metering, relaying etc. Locate on bus side bushings.
- G. One Zero sequence CT for relaying.
- H. Separate backlit LED annunciator with engraved windows for the following circuit breaker status indications:
 - 1. Circuit breaker open
 - 2. Circuit breaker closed
 - 3. Circuit breaker drawn out
- I. Lockout relay, Device 86, Electros witch LOR.
- J. Circuit Breaker Control Switches Momentary Contact, spring-return to center with pistol-grip handle and target to indicate previous operation of the switch. Electros witch Series 24 or accepted substitution.
- K. Set of 3 phase, 1200A, insulated copper bus and ground bus. All joints to be silver plated.
- L. Set of control wiring, alarmed dc control voltage circuit breakers, terminals, nameplates etd. All wiring to be labeled at both ends. Wiring labels to match manufacturers drawings.
- M. Set of crimp type compression lugs for normal power incoming conductors.
- N. Indicating Lights. Refer to paragraph 2.13 this Section. For each feeder breaker provide one (1) Red (close) and one (1) Green (open) pilot light.

2.19 TIE CIRCUIT BREAKER CUBICLE

- A. Provide power and control cubicles in the same vertical section for two each distribution feeder. See plans for quantity. Each vertical section is to contain circuit breakers, instrument transformers, protective relays and power monitoring devices.

- B. Circuit Breaker. Refer to paragraph 2.4 of this Section. References in this Section to normal/utility power circuit breaker means such breakers located in this Emergency Generator Paralleling Switchgear.
- C. Digital multimeter similar to Eaton Power Expert or equal.
- D. Separate backlit LED annunciator with engraved windows for the following circuit breaker status indications:
 - 4. Circuit breaker open
 - 5. Circuit breaker closed
 - 6. Circuit breaker drawn out
- E. Circuit Breaker Control Switches Momentary Contact, spring-return to center with pistol-grip handle and target to indicate previous operation of the switch. Electros witch Series 24 or accepted substitution.
- F. Set of 3 phase, 1200A, insulated copper bus and ground bus. All joints to be silver plated.
- G. Set of control wiring, alarmed dc control voltage circuit breakers, terminals, nameplates etc. All wiring to be labeled at both ends. Wiring labels to match manufacturers drawings.
- H. Set of crimp type compression lugs for normal power incoming conductors.
- I. Indicating Lights. Refer to paragraph 2.13 this Section. For each feeder breaker provide one (1) Red (close) and one (1) Green (open) pilot light.

2.20 SWITCHGEAR ARRANGEMENT

- A. Arrange switchgear with generator circuit breakers, main feeder circuit breakers and master control section arranged as indicated on contract drawings.
- B. Arrange generator and feeder circuit breaker connections to main switchgear bus to ensure that no section of the switchgear main bus is loaded in excess of the ampere rating as specified and as indicated on the Drawings.

2.21 MASTER CONTROL SECTION

- A. Provide a master control section that contains the controls necessary to provide integrated system operations as specified herein.
- B. Automatic. In the automatic mode the functions are to be performed automatically.
- C. Manual. In the manual mode starting and stopping of the individual engine generators are to be controlled through the engine selector switch on each generator control cubicle. Synchronizing in the manual mode is to be performed at the Master Control Section using voltmeter, frequency meter and synchroscope. Closing of the generator circuit breaker is to be controlled through the synchronizing selector switch, the sync-check relay (ANSI Device 25C), and the circuit breaker control switch.
- D. Priority Load Control. Provide output contacts to control priority load blocks. Load shedding is not required at this point however, the capability shall be provided. As the generators are randomly connected to the bus, the controls send a permissive signal to the load blocks in an ascending sequential priority with the highest priority load requiring emergency power being

connected first. Load shedding is to be done on a last-on, first-off basis. Priority load control circuits are to control load blocks by blocking the transfer of lower priority loads to the emergency system until sufficient generation is available and by shedding the lower priority loads on loss of generation capacity to support the connected load.

E. Manual Paralleling Controls:

1. Provide a synchronizing selector switch to select one generator at a time for manual paralleling. The switch is to simultaneously connect a sync-check relay, a synchroscope, and the circuit breaker control switch for the selected engine-generator.
2. Provide a separate, stand-alone, solid-state synchronizing phase band monitor (Device 25C) as a sync check relay. Use the sync check relay to sense and compare the phase angle difference between the oncoming generator and the bus. This relay is to prevent closing the generator circuit breaker until the oncoming generator is within 15 degrees of synchronism.
3. Operation shall be arranged so that the operator will operate the circuit breaker control switch when the oncoming generator is approaching synchronism. Device 25C will inhibit the closing of the oncoming generator circuit breaker until the relative phase angle reduces to 15 degrees and is approaching zero degrees. When the sync check relay is satisfied, it is to provide a permissive signal (i.e., closed contact) to allow the respective generator breaker to close.
4. Bus Under-frequency Protection. Provide a solid-state voltage/frequency monitor (Device 27/59 and 81O/U), with integral time delay to initiate load shedding on a reduction of bus frequency to 58 hertz or less for a period of 2 seconds or more. On sensing a bus under-frequency, the system is to automatically shed the lowest priority load connected at the time of occurrence, and is to continue to shed non-critical load blocks until the bus under-frequency has been corrected. This load shed circuit is to override any manual load-add operation and is to lock out the manual load-add circuitry. It is to give visual and audible alarm annunciation of bus under-frequency load shed, and bus over-frequency, under-voltage, and over-voltage.
5. Ground Fault Alarm. The main bus shall have a neutral to ground bus connection used for the emergency system ground connection. Provide a current sensor and ground fault relay to alarm for system ground faults, while operating on the emergency system. A ground fault status alarm indication shall be provided on the master cubicle. Set relay to pickup and alarm coincident with lowest ground fault alarm setting of protective devices on emergency generator paralleling switchgear, where provided.
6. Instruments and Meters. Provide the following 4-1/2" square switchboard type analog indicating instruments and meters connected to the main bus:
 - a. Voltmeter.
 - b. Frequency meter.
 - c. Synchroscope.
 - d. Coordinate scales with Power Monitoring Device.
 - e. Voltmeter Switch. Provide a switch per paragraph 2.13 to read phase-to-phase voltage and an "off" position.
 - f. Voltage Transformers. Refer to paragraph 2.08 this Section. Provide two (2) 4200-120 volt VTs connected in open delta. Locate in a convenient Section and connect to Main Bus.
 - g. Power Monitoring Device. Provide one (1) per paragraph 2.12 this Section.
 - h. Programmable Logic Controllers. Provide redundant PLCs per paragraph 2.15 this Section.
 - i. Load Shed Bypass-Reset Function. Provide as part of the operator interface panel a means for supervised operation over the load-shed, load-add circuits.

- j. Provide a load-shed bypass-reset function for each priority load block in the system, except priority 1.
- k. Arrange the control system such that in the event a bus overload occurs, reducing the bus frequency, the lowest priority load will be shed automatically.
- l. Each priority load block load-shed bypass-reset function (i.e., 2, 3, and 4) will operate as follows:
 - m. Bypass. Lockout of selected priority load block from control sequence, and removal of its respective load from the switchgear bus.
 - n. Reset. Re-establishment of selected priority load block in the system control sequence, and addition of its respective load to the switchgear bus.
 - o. Main Bus Under-frequency Reset Pushbutton. Provide a function for bus under-frequency reset, to manually reset bus under-frequency load shed signal.
 - p. System Test Switch. Provide a function for system no-load test, to initiate a complete automatic system operation by simulating the closure of the remote engine start signal.
 - q. Master Audible Alarm. Provide a master audible alarm. The alarm horn is to be of the DC vibration type. Include an alarm silencing pushbutton and circuitry to allow subsequent alarms to resound the alarm if the horn had been previously silenced following an initial alarm.
- 7. Description of Operation:
 - a. On a loss of the normal 4.16kV utility source voltage at the paralleling switchgear, a signal is to be generated to initiate an automatic sequence of the engine generators.
 - b. On initiation of the automatic sequence, each engine is to be started. The first engine generator set to achieve 90 percent of nominal voltage and frequency is to be connected to the bus through the multiple circuit interlock discriminator. The highest priority load requiring emergency power is then to be connected. The automatic synchronizers of the remaining engine generator sets are to assume control of the voltage and frequency of the respective sets. When synchronism with the main paralleling bus is achieved, signals will be sent to close the generator circuit breakers by the PCC 3.3 controller. Each remaining load block will then be transferred in priority sequence, until all the loads are connected to the bus. Note that synchronization will be controlled from the Cummins PCC 3.3 controllers.
 - c. Provide circuitry to prevent the automatic transfer of emergency loads to the bus until there is sufficient capacity to carry the loads. Include means to manually override the load addition circuits for supervised operation.
 - d. A priority pass-along circuit is to initiate the connection of low priority loads to the first generator on-line if a signal has not been received from a higher priority transfer switch.
 - e. Design the system so load is reduced automatically on the failure of any engine-generator unit. This mode will override any previous manual controls, in order to prevent overloading the emergency bus. On sensing a failure mode on an engine-generator, the controls are to automatically initiate disconnect, shutdown, lockout of the failed source, and reduce the connected load to within the capacity of the remaining engine-generator unit(s). Controls shall require manual reset.
- 8. Load Demand Control:
 - a. Provide load demand control logic is to sense the load connected to the bus and establish the proper number of sets to operate to maintain the connected load with the minimum on-line reserve generating capacity of 10 percent of the rating of a single set. The load demand control logic is to

- initiate the disconnection of a generator from the bus whenever the on-line reserve generating capacity exceeds 120 percent of a single generator.
- b. The load demand control logic is to have adjustable set points for initiating the addition to, and removal from, the bus of the generator sets. The load demand control logic will sense the bus real load (kW) without the use of thermal transducers or meter relays.
 - c. Include provisions to permit selection of the sequential order of operation of the engine generator sets whenever the system is operating in the load demand control mode. This logic circuitry shall permit revision of the operating order of the engine generator sets at any time without requiring shutdown of on-line sets. Visual indication of sequential assignment shall be provided.
9. Load Demand Control Description of Operation:
- a. After all generator sets have been paralleled to the bus and all loads connected, a stabilization time delay (0-15 minutes), factory set at 15 minutes, is to be initiated. At the expiration of the time delay period, the system will operate in a load demand mode. The load demand control logic and its associated controls will control the number of generating sets on the bus, such that the on-line reserve capacity of the bus is not less than 10 percent, nor more than 120 percent, of the capacity of a single generator set.
 - b. On sensing that the connected load has decreased the reserve capacity to 10 percent or less, initiate a 10-second time delay. This time delay to be field adjustable from 0-300 seconds. If the reserve capacity stays below 10 percent for the duration of the time delay, the controls will initiate the starting and paralleling of the next set in sequence. If, during the time delay period, the reserve capacity decreases to 0 or less (signifying bus overload), the time delay is to be bypassed and the next set in sequence immediately started and paralleled. At the same time, a lamp indicating a bus overload will light and signals will be given to shed load such that the connected priority blocks of load are reduced to equal the number of engine generator sets on line. When the next set is paralleled to the bus, the shed load is to be reconnected and all controls automatically reset.
 - c. Should the next set in sequence have its engine control switch in the "off" position or fail to synchronize within the preset time delay of the "fail-to-synchronize" timer, the controls are to automatically pass the starting signal to the next set in sequence. Provide individual visual and audible alarms to indicate the above conditions.
 - d. If, while operating in the load demand mode, an engine generator set malfunction occurs, the affected set is to be removed from the bus and load priority blocks shed, if necessary, such that the remaining priority blocks connected are equal to the capacity of the remaining engine generators. All idle sets are to start and be paralleled. As the sets are paralleled, loads will be reconnected except for the last priority block which cannot be fed when a generator is down. These last priority loads may be manually added by an operator if it is determined that it will not overload the system. After a generator set malfunction sequence has occurred and all available generator sets have been connected to the bus, a stabilization time delay is re-energized and, upon its expiration, load demand control operation is resumed.
 - e. On sensing that the on-line reserve capacity has increased to 120 percent or more, a 180-second time delay (adjustable 0-300 seconds) is to be initiated. The demand controls shall accept a signal from the BAS that indicates a chiller trip and respond by initiating a time delay equal to the 150% of the

restart cycle time for the chiller. If the reserve capacity stays above 120 percent for the duration of either time delay, open the circuit breaker of the last set brought on line. The engine is to run for its cool-down period, then shut down.

- f. The demand controls shall also accept a signal from the BAS that indicates when another chiller and its auxiliaries will be started. The demand controls shall determine the required generator capacity and shall start additional generators as required. When adequate generator capacity is available for starting the chiller, the demand controls shall initiate a time delay equal to 150% of the start-up sequence time and send a permissive signal to the BAS, which will then allow the start-up sequence for the chiller to commence.

- 10. Alarm and Status Indication:
 Provide visual and audible indication of alarms and status on the master control section, to include readout and annunciation as follows:

<u>Function</u>	<u>Mode</u>
Control Voltage Failure	Alarm
System Controller Failure (Common)	Alarm
Bus Under-frequency (Load Shed)	Alarm
Bus Over-frequency	Alarm
Bus Under-voltage	Alarm
Bus Over-voltage	Alarm
Bus Ground Fault	Alarm
Engine No. 1 Running	Status
Engine No. 1 Lockout	Alarm
Engine No. 1 Trouble (Common Alarm)	Alarm
Engine No. 2 Running	Status
Engine No. 2 Lockout	Alarm
Engine No. 2 Trouble (Common Alarm)	Alarm
Engine No. 3 Running	Status
Engine No. 3 Lockout	Alarm
Engine No. 3 Trouble (Common Alarm)	Alarm
Paralleling Control not in Auto	Status
Engine Control not in Auto (Common)	Status
Load Demand Mode	Status
Feeder Circuit Breaker Trip (Common)	Flashing
System Test (No-Load)	Alarm

Visual alarms are to be re-settable only after the fault condition has been corrected. The audible alarm is to include a silencing circuit with dedicated pushbutton, which after activation will permit audible annunciation of subsequent failures. Provide lamp test feature of all door-mounted visual indicators.

2.22 INFRARED VIEWING WINDOW

- A. Provide a infrared viewing window in the rear doors to allow for viewing of all outgoing conductors from breakers.

PART 3 - EXECUTION

3.1 PROTECTION OF SWITCHGEAR

- A. See Section 26 05 00, Basic Electrical Provisions.

3.2 EQUIPMENT INSTALLATION

- A. Install switchgear as indicated in accordance with manufacturer's written instructions and applicable requirements of the NEC, ANSI, and NEMA.
- B. Field Connections. Make field connections of buses between switchgear sections with splice bus and hardware provided by the switchgear manufacturer.
- C. Tighten electrical bus connections with a torque wrench to manufacturer's recommendations.
- D. Double Lugging. Double lugging on one protected device to feed two separate loads will not be permitted.
- E. Engine Controls. Coordinate with engine-generator for wiring and connection of engine-generator controls between paralleling switchgear and engine-generator control panel. Engine-Generator controls include speed governor, voltage regulator, voltage and speed adjust potentiometers, cross-current compensation transformers if required, isolation transformers, etc.
- F. Equipment Settings. Properly set adjustable time, current and voltage settings as required by Short Circuit and Device Coordination Study furnished by others.
- G. Restoration. Restore damaged surfaces to factory finish.
- H. Inspection. Thoroughly inspect the switchgear for items such as loose connections and presence of foreign materials and remedy prior to energizing the switchgear. Bolted connections shall be torqued to the manufacturer's recommendations.
- I. Prior to energizing of switchgear, megger phase-to-phase and phase-to-ground insulation.
- J. Prior to energizing, check metering and control wiring for correct polarity and proper interconnection.
- K. Subsequent to completion of control and power circuit connections, energize switchgear and verify functioning of metering, controls and protective relaying.
- L. Install nameplate on front door of the switchgear cubicle. In addition, provide a "Danger High Voltage, Keep Out" sign mounted on doors providing access to high voltage, as required by NEC, OSHA, and Owner regulations and/or requirements.
- M. Level switchgear as required for installation of metal platform.

3.3 COMMUNICATIONS

- A. Make provision for communication of engine-generator alarms and other required signals to the emergency generator paralleling switchgear. Provide all necessary control wiring between the master and generator control cubicles and the 5kV paralleling switchgear..
- B. Coordinate with engine-generator units for required alarm signals.
- C. Provide Ethernet and Bacnet communication capability to allow communication between the Master controller and the building energy management system.

- D. The switchgear will be installed on a raised metal platform.

3.4 FIELD SERVICE

- A. Startup. After installation, provide the service of a competent factory-based service engineer to instruct the Contractor and Owner. The service engineer shall assist in placing the equipment into operation and provide instruction, as required, to the person or persons who are designated by the Owner to operate the equipment.
- B. Include three separate visits by the factory service engineer as follows:
 - 1. Pre-installation coordination meeting with the engine generator representative, designer/contractor team and Owner to coordinate the installation and interconnection of the engine generator control switchgear with the engine generator equipment.
 - 2. Post installation startup and testing assistance, prior to system acceptance, and initial instruction and training period for operating personnel. Include service required to checkout the emergency system and demonstrate the operation for final acceptance by the owner.
 - 3. After system acceptance, provide instruction for operating personnel on complete operation and maintenance program. Time, duration, and location of training visit as designated by Owner.
- C. Maintain a competent service organization that is available on a 24-hour call basis.

3.5 FIELD TESTING

- A. Provide complete on site field testing of the system demonstrating.
- B. Notify the Engineer and the Owner's Representative 14 working days in advance of this test date so the tests can be properly witnessed.
- C. After completion of field- testing, restore permanent electrical distribution system connections. Repair connections, terminations, or conductors damaged or found to be defective during the system full load test.

END OF SECTION

SECTION 26 43 13

SURGE PROTECTION DEVICE SECTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including "Uniform General Conditions and Supplementary General Conditions for the State of Texas Building Construction Contracts", and Division 01 sections apply to the work of this Section.

1.02 SUMMARY

- A. This Section specifies the furnishing and installing of type 1 Surge Protective Devices (SPDs), used as a component of a facility-wide suppression system implemented in conjunction with type 2 SPDs in branch circuit panelboards. The specified unit installed in the facility-wide suppression system shall provide effective high-energy transient voltage suppression, surge current diversion, and line control in high-exposure ANSI/IEEE C62.41-1991 environments on the load side of the facility main overcurrent protective device (OCPD). Units installed in the facility-wide suppression system are indicated by the designation SPD (Surge Protection Device) on Drawings.

1.03 STANDARDS

- A. The specified units installed in the facility-wide suppression system shall be designed, manufactured, tested, and installed in compliance with the following standards:
- B. American National Standards Institute and Institute of Electrical and Electronic Engineers:
 - 1. ANSI/IEEE C62.41.1, Recommended Practice for Surge Voltages in Low-Voltage AC power Circuits.
 - 2. ANSI/IEEE C62.45, Guide for Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
- C. IEEE Standard 1100-1999 (Emerald Book): Powering and Grounding Sensitive Electronic Equipment.
- D. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
- E. Military Standards (MIL-STD 220A).
- F. National Electrical Manufacturers Association (NEMA LS1-1992/R2000).
- G. National Fire Protection Association (NFPA):
 - 1. NFPA 75, Protection of Information Technology Equipment.

2. NFPA 70, National Electrical Code (NEC), Article 285.

H. Underwriters Laboratories (UL):

1. UL 248, Low Voltage Fuses.
2. UL 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
3. UL 1449 Third Edition, Surge Protection Devices.

1.04 RELATED WORK

- A. Section 26 24 16, Panelboards – Distribution and Branch Circuit.
- B. Section 26 43 13, Surge Protection Device.
- C. Section 26 05 73, Overcurrent Protective Device Coordination Study.

1.05 SUBMITTALS

- A. Factory Tests: Furnish certified documentation for the following tests:
 1. Package must include shop drawings complete with all technical information unit dimensions, detailed installation instructions, maintenance manual, recommended replacement parts list and wiring configuration.
 2. Copies of Manufacturer's catalog data, technical information and specifications on equipment proposed for use.
 3. Copies of documentation stating that the Surge Protection Device is listed from a Nationally Recognized Testing Laboratory (NRTL) (UL, ETL, etc) and are tested and multi-listed to UL 1449 3rd Edition and UL 1283.
 4. Copies of actual let through voltage data in the form of oscilloscope results for both ANSI/IEEE C62.41 Category C3 (combination wave) and B3 (Ring wave) tested in accordance with ANSI/IEEE C6245.
 5. Copies of Noise Rejection testing as outlined in NEMA LS1-1992 (R2000) Section 3.11. Noise rejection is to be measured between 50 kHz and 100 MHz verifying the devices noise attenuation. Must show multiple attenuation levels over a range of frequencies.
 6. Copies of test reports from a recognized independent testing laboratory, capable of producing 200kA surge current waveforms, verifying the suppressor components can survive published surge current rating on a per mode basis using the ANSI/IEEE C62.41 impulse waveform C3 (8 x 20 microsecond, 20 kV/10kA). Test data on an individual module is not acceptable.
 7. Copies of test reports from a recognized independent testing laboratory indicating the results of nominal discharge current test at values 20 kA/mode. The nominal discharge current test must be conducted per UL 1449 Third Edition.
 8. Copy of warranty statement clearly establishing the terms and conditions to the building/facility owner/operator.

- B. Product Data: Submit complete product data and catalog cutsheets describing each unit provided. Make submittals in accordance with the requirements of Division 01 and Section 26 00 00, Electrical General Provisions.
- C. Field Testing: Submit written procedures and forms to be used for field testing to demonstrate compliance with these specifications, as required under Part 3 of this Section. Testing procedures and forms shall include range of permissible values for each recorded parameter. Include list of test instruments and materials to be used for field testing, to include manufacturer, model, accuracy, and applicable steps of field testing procedures.
- D. Submittals after fabrication:
 - 1. Instruction manual describing each unit provided. Manual shall conform to the requirements of Operations and Maintenance (O&M) manuals per Section 26 00 00, Electrical General Provisions.
 - 2. Spare Parts: A list of customer-replaceable spare parts for each unit installed in the facility-wide suppression system shall be included in the unit installation, operation and maintenance instructions. Spare parts shall be quickly and easily field-replaceable.
 - 3. Field Testing: Submit to the Owner's Representative and to the Architect/Engineer documentation of field testing performed in accordance with Part 3 of this Section, demonstrating compliance with the requirements of this Section. Where not specified otherwise, provide three copies to the Architect/Engineer and one copy to the Owner's Representative.
- E. Panelboards: Refer to Section 26 24 16, Panelboards – Distribution and Branch Circuit, for submittal requirements for distribution and branch circuit panelboards as indicated in Construction Drawings.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Square D
- B. GE
- C. Current Technology
- D. Eaton.

2.02 SPD RATINGS

- A. Refer to drawings for operating voltage, configuration.
- B. Declared Maximum Continuous Operating Voltage (MCOV) shall be greater than 115 percent of the nominal system operating voltage and in compliance with test and evaluation procedures outlined in the nominal discharge surge current test of UL1449 3rd

Edition, section 37.7.3. MCOV values claimed based on the component's value or on the 30-minute 115% operational voltage test, section 38 in UL1449 will not be accepted.

- C. Unit shall have not more than 10% deterioration or degradation of the UL1449 3rd Edition Voltage Protection Rating (VPR) due to repeated surges. Unit shall have a monitoring option available to be able to test and determine the percentage of protection available at all times.
- D. Protection Modes of UL1449 3rd Edition Voltage Protection Rating (VPR) (6kV, 3kA) for grounded WYE/delta and with voltages of (480Y/277). 3-Phase, 4 wire circuits.
- E. Provide equipment with an integral disconnect with the following ratings:

System Voltage	Mode	MCOV	B3 Ringwave	C3 Comb. Wave	UL 1449 Third Edition VPR Rating
120/208	L-G	150	400	650	700
	N-G	0	350	500	900
	L-L	300	400	950	900
277/480	L-N	320	550	1125	900
	L-G	320	850	1075	1200
	N-G	0	700	900	1200
	L-L	550	650	1950	1800

- F. If SPDs are submitted with integral disconnect ratings must be adjusted to comply with UL 1449 3rd Edition.
- G. Provide SPDs with nominal discharge current rating of 20kA/mode.
- H. Surge Rating - Provide SPDs with a minimum surge rating of 200kA per mode.
- I. Electrical Noise Filter- each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric noise shall be as follows using the MIL-STD-220A insertion loss test method.
 1. 100 kHz at 41 db.
 2. All other frequencies should be 31 db or better.
- J. Each Unit shall provide the following features:
 1. Phase Indicator lights, Form C dry contacts, counter and audible alarm.
 2. Field testable while installed.
- K. Suppression/Filter System: UL 1283 minimum insertion loss obtained utilizing MIL-STD-E220A 50 ohm insertion loss methodology. (100 kHz - 1 MHz): 34 dB (50:1).

2.03 FUSING

- A. Fuse Components Identification and Surge Rating: The surge rating (8 x 20 μ sec) of the fuse shall be greater than the combined surge current rating of downstream connected suppression elements.
- B. Suppression Components Identification and Surge Rating: The suppression elements connected in series with fuse elements shall provide the suppression elements published 8 x 20 μ sec surge current rating. The rating of the suppression elements shall be less than the rating of upstream fusing elements.
- C. Surge Performance: Fusing shall be required to meet the single pulse surge current testing requirements described above.
- D. Isolation: The unit shall have each MOV fused and designed to operate only in the event of a MOV failure within the unit.
- E. UL Rating: Fusing shall be 200kAIC UL248 Recognized.

2.04 BUSSING

- A. Transient Conduction Path: Full magnitude transient currents shall be conducted on low-impedance solid copper bussing. Printed circuit boards traces shall not be used to conduct or shunt transient voltage surge currents.

2.05 MONITORING

- A. Visual: Monitoring shall include one set of status monitoring lights that will provide visual indication of voltage present to the SPD for each phase of protection. The lights shall also indicate when suppressor protection has degraded to a value of less than 50%.
- B. Alarm: The unit shall include an audible alarm with battery backup, a current-sensing surge counter, and two sets of Form C contacts for remote monitoring.

2.06 ENCLOSURE

- A. Provide a SPD assembly that is UL listed.
 - 1. If required to maintain a UL listing of both the SPD and the associated distribution equipment, then provide the SPD in a separate NEMA Type 12 enclosure sized per the SPD manufacturer's recommendations. Install the SPD per manufacturer recommendations. Install the externally mounted SPD so that the conductor length is a maximum of 5'-0".
 - 2. Where UL listed for installation in the equipment, the arrangement of the SPD within the enclosure shall match and maintain the full wiring gutter fill capacity of the associated electrical equipment.
- B. Finish: Exterior and interior steel surfaces shall be cleaned and finished with electrostatically applied "powder coat" thermoset enamel baked over a rust-inhibiting

phosphatized coating. Exterior finish color shall be manufacturer's standard gray, ANSI 49 or ANSI 61, to match finish of associated panelboard.

2.07 LISTING

- A. Units shall be UL 1449, Third Edition, listed and labeled as a Type 1 Surge Protection Device.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver surge protection devices, components and accessories individually wrapped, on pallets or in factory-fabricated fiberboard type containers, and protected from weather and damage.
- B. Store surge protection devices, components and accessories in a clean and dry space, elevated above grade, and protected from weather, sunlight, moisture, dirt, and corrosion.
- C. Surge protection devices, components, and accessories shall not be used as work tables, scaffolds, or ladders.
- D. Handle surge protection devices, components, and accessories carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damaged products shall be rejected and not be installed on project.
- E. Refer to Section 26 00 00, Electrical General Provisions.

3.02 INSTALLATION

- A. General: Install surge protection device (SPD) internal to the electrical distribution equipment in accordance with manufacturer's wiring diagrams and written instructions and the applicable requirements of the NEC, NEMA, ANSI, local codes, and Owner requirements.
- B. Install the SPD enclosure, or enlarge enclosure to house SPD as required, to the top or bottom of the panelboard at end opposite from the main circuit breaker or main lugs. Extend phase conductors from SPD to disconnecting means in the electrical equipment, as indicated on Drawings. Extend neutral and ground conductors from SPD to lugs at the neutral and ground busses, in accordance with manufacturer instructions. Connection leads shall not exceed 18 inches from the SPD to the circuit breakers:
 - 1. Where not otherwise indicated or specified, terminate SPD phase conductors to three single-pole circuit breakers in the panelboard connected by a handle tie.
 - 2. Where manufacturer instructions and UL-listing require a 3-pole circuit breaker as disconnecting means and overcurrent protection for the surge protection device, provide a 3-pole circuit breaker as the disconnecting means between the SPD and main bus.

3. Provide overcurrent device for SPD connection to panelboard main bus, sized in accordance with manufacturer recommendations. Refer to Section 26 24 16, Panelboards – Distribution and Branch Circuit.
- C. Wire Size: Manufacturer's recommended wire size for unit supplied. Where wire size is not indicated by manufacturer, provide conductors of same size as grounding conductor connected to the ground bus of the panelboard, #2 AWG minimum per phase, neutral, and ground. Use stranded copper conductor with THWN insulation, unless otherwise noted.
- D. Equipment interiors shall be maintained clean until final Owner acceptance. Equipment exteriors shall be maintained free of mud, spray-on insulation, paint spray and other substances not placed on the exterior surface by the equipment manufacturer.
- E. Inspection: Thoroughly inspect surge protection device and panelboard for items such as loose connections and presence of foreign materials and remedy prior to energizing the panelboard. Bolted connections shall be torqued to the manufacturer's recommendations.

3.03 SYSTEM TESTING

- A. Upon completion of installation, provide the start-up and testing services of a factory-authorized and factory-trained local service representative. The tests shall include:
 1. Off-Line testing: Impulse injection to verify the system tolerances as well as verification of proper facility neutral-to-ground bond. Compare field test results to factory benchmark test parameters supplied with each individual unit.
 2. On-Line testing: Verification that suppression and filtering paths are operating with 100% protection as well as verification of proper facility neutral-to-ground bond by measuring neutral-to-ground current and voltage and by visual inspection.
 3. Voltage measurements from Line-to-Ground (L-G), Line-to-Neutral (L-N), Line-to-Line (L-L), and Neutral-to-Ground (N-G), taken at the time of the testing procedure.

3.04 DOCUMENTATION AND REPORTING

- A. Record results of field testing and compare to factory benchmark test parameters supplied with each individual surge protection device. Indicate that the integrity of neutral-to-grounds bonds was verified through testing and visual inspection, and that grounding bonds were observed to be in place.
- B. Submit to the Owner's Representative and to the Architect/Engineer copies of the startup test results and the factory benchmark testing results for confirmation of proper suppression filter system function, as required by paragraph PART 1 -1.05D.3, this Section. Provide number of copies as required by Division One and Section 26 00 00, Electrical General Provisions; and three copies where not otherwise specified.

3.05 SYSTEM WARRANTY

- A. The SPD system shall be warranted against defective materials and workmanship for a period of ten years.

- B. Warranties shall conform to the requirements of Division 01 and Section 26 00 00, Electrical General Provisions.

END OF SECTION 26 43 13

SECTION 26 43 15

SURGE PROTECTION DEVICES IN PANELBOARD EXTENSIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including "Uniform General Conditions and Supplementary General Conditions for the State of Texas Building Construction Contracts", and Division 01 sections apply to the work of this Section.

1.2 SUMMARY

- A. This Section specifies the furnishing and installing of type 2 Surge Protective Devices (SPDs) to provide effective transient voltage surge suppression, and surge current diversion in all electrical modes for equipment connected to distribution and branch circuit panelboards designated on Drawings as an "Electronic Grade" panelboards (EGPs) or having SPDs. The units shall be located in an enclosure that becomes an extension to the branch circuit panelboards, and shall be connected in parallel with the facility wiring system.
- B. Refer to Section 26 24 15 for requirements pertaining to Distribution Panelboards and 26 24 16 for requirements pertaining to Branch Circuit Panelboards.

1.3 STANDARDS

- A. The specified units installed in the facility-wide suppression system shall be designed, manufactured, tested, and installed in compliance with the following standards:
- B. American National Standards Institute and Institute of Electrical and Electronic Engineers:
 - 1. ANSI/IEEE C62.41.1, Recommended Practice for Surge Voltages in Low-Voltage AC power Circuits.
 - 2. ANSI/IEEE C62.45, Guide for Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
- C. IEEE Standard 1100-1999 (Emerald Book): Powering and Grounding Sensitive Electronic Equipment.
- D. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
- E. Military Standards (MIL-STD 220A).
- F. National Electrical Manufacturers Association (NEMA LS1-1992/R2000).
- G. National Fire Protection Association (NFPA):
 - 1. NFPA 75, Protection of Information Technology Equipment.
 - 2. NFPA 70, National Electrical Code (NEC), Article 285.
- H. Underwriters Laboratories (UL):
 - 1. UL 248, Low Voltage Fuses.
 - 2. UL 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

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3. UL 1449 Third Edition, Surge Protection Devices.

1.4 RELATED WORK

- A. 26 24 15, Distribution Panelboards
- B. Section 26 24 16, Panelboards –Branch Circuit.
- C. Section 26 43 13, Surge Protection Device.
- D. Section 26 05 73, Overcurrent Protective Device Coordination Study.

1.5 SUBMITTALS

- A. Factory Tests: Furnish certified documentation for the following tests:
 1. Package must include shop drawings complete with all technical information unit dimensions, detailed installation instructions, maintenance manual, recommended replacement parts list and wiring configuration.
 2. Copies of Manufacturer's catalog data, technical information and specifications on equipment proposed for use.
 3. Copies of documentation stating that the Surge Protection Device is listed from a Nationally Recognized Testing Laboratory (NRTL) (UL, ETL, etc) and are tested and multi-listed to UL 1449 3rd Edition and UL 1283.
 4. Copies of actual let through voltage data in the form of oscilloscope results for both ANSI/IEEE C62.41 Category C3 (combination wave) and B3 (Ring wave) tested in accordance with ANSI/IEEE C6245.
 5. Copies of Noise Rejection testing as outlined in NEMA LS1-1992 (R2000) Section 3.11. Noise rejection is to be measured between 50kHz and 100MHz verifying the devices noise attenuation. Must show multiple attenuation levels over a range of frequencies.
 6. Copies of test reports from a recognized independent testing laboratory, capable of producing 200kA surge current waveforms, verifying the suppressor components can survive published surge current rating on a per mode basis using the ANSI/IEEE C62.41 impulse waveform C3 (8 x 20 microsecond, 20kV/10kA). Test data on an individual module is not acceptable.
 7. Copies of test reports from a recognized independent testing laboratory indicating the results of nominal discharge current test at values of 10kA for branch circuit panelboards and 20kA for distribution panelboards. The nominal discharge current test must be conducted per UL 1449 Third Edition.
 8. Copy of warranty statement clearly establishing the terms and conditions to the building/facility owner/operator.
- B. Product Data: Submit complete product data and catalog cutsheets describing each unit provided. Make submittals in accordance with the requirements of Division One and Section 26 00 00, Electrical General Provisions.
- C. Field Testing: Submit written procedures and forms to be used for field testing to demonstrate compliance with these specifications, as required under Part 3 of this Section. Testing procedures and forms shall include range of permissible values for each recorded parameter. Include list of test instruments and materials to be used for field testing, to include manufacturer, model, accuracy, and applicable steps of field testing procedures.
- D. Submittals after fabrication:

1. Instruction manual describing each unit provided. Manual shall conform to the requirements of Operations and Maintenance (O&M) manuals per Section 26 00 00, Electrical General Provisions.
 2. Spare Parts: A list of customer-replaceable spare parts for each unit installed in the facility-wide suppression system shall be included in the unit installation, operation and maintenance instructions. Spare parts shall be quickly and easily field-replaceable.
 3. Field Testing: Submit to the Owner's Representative and to the Architect/Engineer documentation of field testing performed in accordance with Part 3 of this Section, demonstrating compliance with the requirements of this Section. Where not specified otherwise, provide three copies to the Architect/Engineer and one copy to the Owner's Representative.
- E. Panelboards: Refer to Section 26 24 16, Panelboards – Distribution and Branch Circuit, for submittal requirements for distribution and branch circuit panelboards as indicated in Construction Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Square D,
- B. GE
- C. Current Technology
- D. Eaton

2.2 SPD RATINGS

- A. Refer to drawings for operating voltage, configuration.
- B. Declared Maximum Continuous Operating Voltage (MCOV) shall be greater than 115 percent of the nominal system operating voltage and in compliance with test and evaluation procedures outlined in the nominal discharge surge current test of UL1449 3rd Edition, section 37.7.3. MCOV values claimed based on the component's value or on the 30-minute 115% operational voltage test, section 38 in UL1449 will not be accepted. Unit shall have not more than 10% deterioration or degradation of the UL1449 3rd Edition Voltage Protection Rating (VPR) due to repeated surges. Unit shall have a monitoring option available to be able to test and determine the percentage of protection available at all times.
- C. Protection Modes of UL1449 3rd Edition Voltage Protection Rating (VPR) (6kV, 3kA) for grounded WYE/delta and with voltages of (480Y/277), (208Y/120). 3-Phase, 4 wire circuits.
- D. Provide equipment with an integral disconnect with the following ratings:

System Voltage	Mode	MCOV	B3 Ringwave	C3 Comb. Wave	UL 1449 Third Edition VPR Rating
120/208	L-G	150	400	650	700
	N-G	0	350	500	900
	L-L	300	400	950	900
277/480	L-N	320	550	1125	900
	L-G	320	850	1075	1200
	N-G	0	700	900	1200
	L-L	550	650	1950	1800

- E. If SPDs are submitted with integral disconnect ratings must be adjusted to comply with UL 1449 3rd Edition.
- F. Provide SPDs with nominal discharge current ratings as follows:
 - 1. Branch circuit panelboards – 10kA
 - 2. Distribution panelboards – 20kA
- G. Surge Rating - provide SPDs with minimum surge ratings as follows:
 - 3. EGPs - 150kA per mode.
 - 4. Branch circuit panelboards used as service entrance equipment shall be provided with a Type 1 SPD that complies with the requirements of Section 26 43 13.
 - 5. Branch circuit panelboards not specifically identified as being an EGP or not used as service entrance equipment shall be provided with a minimum surge rating of 80kA per mode.
- H. Electrical Noise Filter- each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric noise shall be as follows using the MIL-STD-220A insertion loss test method.
 - 6. 100 kHz at 41 db.
 - 7. All other frequencies should be 31 db or better.
- I. Each Unit shall provide the following features:
 - 8. Phase Indicator lights, Form C dry contacts, counter and audible alarm.
 - 9. Field testable while installed.
- J. Suppression/Filter System: UL 1283 minimum insertion loss obtained utilizing MIL-STD-E220A 50 ohm insertion loss methodology. (100 kHz - 1 MHz): 34 dB (50:1).

2.3 FUSING

- A. Fuse Components Identification and Surge Rating: The surge rating (8 x 20 μsec) of the fuse shall be greater than the combined surge current rating of downstream connected suppression elements.
- B. Suppression Components Identification and Surge Rating: The suppression elements connected in series with fuse elements shall provide the suppression elements published 8 x 20 μsec surge current rating. The rating of the suppression elements shall be less than the rating of upstream fusing elements.

- C. Surge Performance: Fusing shall be required to meet the single pulse surge current testing requirements described above.
- D. Isolation: The unit shall have each MOV fused and designed to operate only in the event of a MOV failure within the unit.
- E. UL Rating: Fusing shall be 200kAIC UL248 Recognized.

2.4 BUSSING

- A. Transient Conduction Path: Full magnitude transient currents shall be conducted on low-impedance solid copper bussing. Printed circuit boards traces shall not be used to conduct or shunt transient voltage surge currents.

2.5 MONITORING

- A. Visual: Monitoring shall include one set of status monitoring lights that will provide visual indication of voltage present to the SPD for each phase of protection. The lights shall also indicate when suppressor protection has degraded to a value of less than 50%.
- B. Alarm: The unit shall include an audible alarm with battery backup, a current-sensing surge counter, and two sets of Form C contacts for remote monitoring.

2.6 ENCLOSURE

- A. Units shall be provided in a NEMA Type 12 enclosure that is the same width and depth as the branch circuit panelboard or distribution panelboard to which it is connected, or interior to the equipment itself.
- B. The arrangement of the SPD within the enclosure shall match and maintain the full wiring gutter fill capacity of the associated panelboard.
- C. Finish: Exterior and interior steel surfaces shall be cleaned and finished with electrostatically applied "powder coat" thermoset enamel baked over a rust-inhibiting phosphatized coating. Exterior finish color shall be manufacturer's standard gray, ANSI 49 or ANSI 61, to match finish of associated panelboard.

2.7 LISTING

- A. Units shall be UL 1449, Third Edition, listed and labeled as a Type 2 Surge Protection Device.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Deliver surge protection devices, components and accessories individually wrapped, on pallets or in factory-fabricated fiberboard type containers, and protected from weather and damage.
- B. Store surge protection devices, components and accessories in a clean and dry space, elevated above grade, and protected from weather, sunlight, moisture, dirt, and corrosion.

- C. Surge protection devices, components, and accessories shall not be used as work tables, scaffolds, or ladders.
- D. Handle surge protection devices, components, and accessories carefully to avoid damage to material components, enclosure and finish. Use only lifting eyes and brackets provided for that purpose. Damaged products shall be rejected and not be installed on project.
- E. Refer to Section 26 00 00, Electrical General Provisions.

3.2 INSTALLATION

- A. General: Install surge protection device (SPD) internal to the electrical distribution equipment in accordance with manufacturer's wiring diagrams and written instructions and the applicable requirements of the NEC, NEMA, ANSI, local codes, and Owner requirements.
- B. Install the SPD enclosure, or enlarge enclosure to house SPD as required, to the top or bottom of the panelboard at end opposite from the main circuit breaker or main lugs. Extend phase conductors from SPD to disconnecting means in the panelboard, as indicated on Drawings. Extend neutral and ground conductors from SPD to lugs at the neutral and ground busses, in accordance with manufacturer instructions. Connection leads shall not exceed 18 inches from the SPD to the circuit breakers:
 - 1. Where not otherwise indicated or specified, terminate SPD phase conductors to three single-pole circuit breakers in the panelboard connected by a handle tie.
 - 2. Where manufacturer instructions and UL-listing require a 3-pole circuit breaker as disconnecting means and overcurrent protection for the surge protection device, provide a 3-pole circuit breaker as the disconnecting means between the SPD and main bus.
 - 3. Provide overcurrent device for SPD connection to panelboard main bus, sized in accordance with manufacturer recommendations. Refer to Section 26 24 16, Panelboards – Distribution and Branch Circuit.
- C. Wire Size: Manufacturer's recommended wire size for unit supplied. Where wire size is not indicated by manufacturer, provide conductors of same size as grounding conductor connected to the ground bus of the panelboard, #2 AWG minimum per phase, neutral, and ground. Use stranded copper conductor with THWN insulation, unless otherwise noted.
- D. Equipment interiors shall be maintained clean until final Owner acceptance. Equipment exteriors shall be maintained free of mud, spray-on insulation, paint spray and other substances not placed on the exterior surface by the equipment manufacturer.
- E. Inspection: Thoroughly inspect surge protection device and panelboard for items such as loose connections and presence of foreign materials and remedy prior to energizing the panelboard. Bolted connections shall be torqued to the manufacturer's recommendations.

3.3 SYSTEM TESTING

- A. Quality Assurance Testing: Test each unit at factory prior to shipment
- B. Upon completion of installation, provide the start-up and testing services of a factory-authorized and factory-trained local service representative. The tests shall include:
 - 1. Off-Line testing: Impulse injection to verify the system tolerances as well as verification of proper facility neutral-to-ground bond. Compare field test results to factory benchmark test parameters supplied with each individual unit.

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2. On-Line testing: Verification that suppression and filtering paths are operating with 100% protection as well as verification of proper facility neutral-to-ground bond by measuring neutral-to-ground current and voltage and by visual inspection.
3. Voltage measurements from Line-to-Ground (L-G), Line-to-Neutral (L-N), Line-to-Line (L-L), and Neutral-to-Ground (N-G), taken at the time of the testing procedure.

3.4 DOCUMENTATION AND REPORTING

- A. Record results of field testing and compare to factory benchmark test parameters supplied with each individual surge protection device. Indicate that the integrity of neutral-to-grounds bonds was verified through testing and visual inspection, and that grounding bonds were observed to be in place.
- B. Submit to the Owner's Representative and to the Architect/Engineer copies of the startup test results and the factory benchmark testing results for confirmation of proper suppression filter system function, as required by paragraph 1.04D.3, this Section. Provide number of copies as required by Division One and Section 26 00 00, Electrical General Provisions; and three copies where not otherwise specified.

3.5 SYSTEM WARRANTY

- A. The SPD system shall be warranted against defective materials and workmanship for a period of ten years.
- B. Warranties shall conform to the requirements of Division 01 and Section 26 00 00, Electrical General Provisions.

END OF SECTION

SECTION 26 51 00

INTERIOR AND EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the furnishing and installation of luminaires complete with lamps, ballasts, and other accessories. Provide poles for exterior luminaires requiring such.

1.2 REFERENCE STANDARDS

- A. ANSI C78 Series - Lamps.
- B. ANSI C82 Series - Ballasts.
- C. ANSI/UL 935 - Fluorescent-Lamp Ballasts.
- D. EPA SW 846 - Test Methods for Evaluating Solid Waste.
- E. NFPA 70 - National Electrical Code (NEC).
- F. NFPA 101 - Life Safety Code.
- G. UL 924 - Emergency Lighting and Power Equipment.

1.3 RELATED WORK

- A. Section 26 00 00, Electrical General Provisions.
- B. Section 26 05 33, Raceways.

1.4 SUBMITTALS

- A. Submit product data on each luminaire, emergency lighting unit, exit sign, and pole, with separate sheet for each luminaire, assembled by luminaire "type" in alphabetical order, with the proposed luminaire, ballast or Driver, lamps, and accessories clearly labeled. Submit at one time in booklet form.
 - 1. Include with submittal data dimensioned drawings and performance data including coefficients of utilization, candela distribution, spacing to mounting height ratio, efficiency, efficacy, and visual comfort probability.
- B. LED: Provide documentation for performance of LED luminaires including LM 79, LM 80 reports and L70, L80 or L85 test results. Provide documentation for listed tolerances for variation in temperature color, or "binning". Binning documentation shall include MacAdam steps diagram with range of binning clearly indicated. Provide testing data that clearly indicates listed environmental conditions for installation of luminaire including ambient temperature.
 - 1. LED luminaires with remote drivers shall clearly indicate required wattage and voltage tolerance of driver and maximum range for which driver can be installed remote to LED luminaire.

2. Provide power requirements for complete LED fixture package clearly indicating the lumen package and power consumption of the entire fixture package.
 - a. Data indicating only lumen package and power requirements for individual LED modules incorporated into the complete fixture package is not acceptable.
- C. Samples.
 1. When requested in writing by the Owner's Representative or the Architect/Engineer, furnish samples of luminaire types.
 2. Deliver samples for luminaire types as requested, at a time and place designated by the requestor (Owner's Representative or the Architect/Engineer).
 3. Samples shall be complete product models as proposed for use on the project.
 4. Furnish samples to the Owner at no additional cost.
 - a. Samples shall not be installed on the project without the written consent of the Owner's Representative and the Architect/Engineer.
 - b. Upon written concurrence from the Owner's Representative, samples furnished for the project may be retained by the Contractor for delivery as "spares" following Owner's acceptance of the completed project.

PART 2 - PRODUCTS

2.1 LUMINAIRES

1. See plans.

2.2 LAMPS

- A. General. Provide lamps for luminaires. Types are specified in the Luminaire Schedule on the Drawings.
- B. Light Emitting Diodes (LED) or Solid State Lighting
 1. Provide luminaire package with temperature variance limited to three MacAdam steps as defined in ANSI C78.377.
 2. Provide luminaire that is factory tested as a complete package with a LM-79 and LM-80 report.
 3. Provide luminaire with individual LED boards. Replacement of individual LED boards shall be capable to be performed in the field and shall not require replacement of the entire unit or fixture.
 4. Provide fixture with minimum 5 year warranty covering complete luminaire package.
 5. Provide LEDs with phosphorous coating, for creation of white LEDs, at the individual LEDs and not at the luminaire lens or housing.
 6. Provide luminaire with quick disconnect for LED drivers and individual LED boards.
 7. Provide LED fixtures compatible with 0-10V or DALI non-proprietary controls.
 8. Provide LED luminaires with appropriately sized heat sink.

2.3 BALLASTS

- A. General. Provide ballasts for luminaires as required and as scheduled.
- B. Light Emitting Diode (LED) Drivers
 1. UL Listed as a complete assembly with luminaire,
 2. RoHS and FCC compliant.
 3. Minimum 5 year warranty.
 4. Comply with NEMA 410 for in-rush current limits.
 5. UL Class 2 power limited per UL1310.

6. UL dry and damp location listed.
7. Power factor greater than 0.90 and <20% THD.
8. Driver shall operate at specified input voltage with sustained variation of +/- 10% with no damage to the driver.
9. Integral surge protective device.
10. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
11. Minimum operating temperature -20C.
12. Driver output regulated +/- 5% over published load range. Output shall be compatible with LED board in specified luminaire.
13. Output current controls local to the driver (trimpot or programmable).
14. If specified on the Drawings, the driver shall dim within the range specified on the fixture schedule with no flicker.
15. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.

C. Listings.

1. LED - UL1310 - Class 2 power supplies

2.4 EMERGENCY BATTERY PACK/BALLAST

- A. Where indicated on luminaire schedule or plans, provide luminaires with emergency ballasts. Emergency ballasts shall automatically provide for a minimum of 90 minutes of illumination in the event of loss of normal power to the building. Where larger capacity is indicated on plans or schedules, provide unit with larger capacity.
- B. Emergency battery packs/ballasts shall comply with the following requirements:
1. Exceed the NEC, LSC, and UL 90-minute requirements, and carry the UL label.
 2. Contain high-temperatures nickel cadmium batteries that are maintenance free and fully recharge within 24 hours.
 3. Are backed by full (non pro-rata) warranties, 5-year for linear fluorescent lamps and 2-year for compact fluorescent lamps.
 4. Capable of operating one or two lamps, with minimum lumen output as indicated on the Drawings.
- C. Manufacturer. Bodine, and the scheduled luminaire manufacturers.

2.5 EMERGENCY LIGHTING UNITS

- A. See plans.

2.6 EXIT SIGNS

- A. See plans.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

- A. Deliver luminaires, exit signs, emergency lighting units, and accessories individually wrapped in factory-fabricated fiberboard type containers.
- B. Handle luminaires, exit signs, emergency lighting units, and accessories carefully to prevent breakage, denting and scoring the luminaire finish. Do not install damaged units.

- C. Store luminaires, exit signs, emergency lighting units, and accessories in a clean, dry space, elevated above grade, and protected from the weather and sunlight.
- D. Refer to paragraph 3.2 of Section 26 00 00, Electrical General Provisions.

3.2 COORDINATION

- A. Prior to ordering luminaires, check the type of ceilings to be installed in each room and verify that the luminaires are proper and compatible for the type of ceiling as specified and as indicated on the architectural Drawings. Provide a frame compatible with the type of ceiling in which the luminaire is installed. Refer to the Drawings and the Architectural Room Finish Schedule for the specified ceiling type. Advise the Owner's Representative of discrepancies before placing the luminaire order.
- B. Check the building electrical system requirements and architectural finishes, and regardless of the catalog number prefixes and suffixes shown, furnish luminaires with the proper trim, frames, plaster rings, supports, hangers, stems, mounting brackets, ballasts, voltage rating, and other miscellaneous appurtenances to properly coordinate with said conditions. Verify with Owner's Representative prior to ordering.
- C. If a luminaire type designation is omitted, furnish luminaire of the same type as shown for rooms of similar usage. Verify with Owner's Representative before purchase and installation.
- D. Examine the areas and conditions which luminaires are to be installed and notify the Owner's Representative and the Architect/Engineer in writing of conditions detrimental to the proper and timely completion of the work. Include written plan for correction of deficiencies and conditions noted. Do not proceed with the work until unsatisfactory conditions have been corrected.
- E. Verify that the occupancy sensors are compatible with the specified ceiling systems as indicated on the Drawings. Advise the Architect/Engineer of discrepancies before placing the device order.
- F. Verify that the fluorescent dimmers are compatible with the specified dimming ballasts, as indicated on Drawings.
- G. Coordinate luminaire installation with lighting controls per Section 26 09 23, with architectural dimming system per Section 26 09 33, and with digital network addressable lighting controls per Section 26 09 43.

3.3 INSTALLATION

- A. Install luminaires in accordance with the manufacturer's written instructions, Owner's requirements, the applicable requirements of NEC and local and national Codes, Standards, and regulations.
- B. Install luminaires at locations as shown on the Drawings, install aligned, aimed, and leveled. Install luminaires in accordance with manufacturer's installation instructions complete with mounting accessories, trim and support materials.
- C. Support.
 - 1. Provide hangers and support members for luminaires as required for proper installation. Provide appurtenances which include stud supports, stems, mounting brackets, frames and plaster rings.

2. Support luminaires from the building structure or from furring channels. Furring channels must be a minimum size of 1-1/2 inches. Luminaires in suspended ceilings shall be supported in accordance with NEC 410.16.
 3. Fasten luminaires securely to structural support members of the building. Support grid-type lay-in luminaires from the structure above at each corner of luminaire. 1/4 inch expansion slip ring anchorage with eye and ceiling-type support wire is permitted. Two wires may be supported by one anchorage if required by construction conditions, such as obstructions by other system. Solid pendant luminaires shall be plumb.
 4. Provide support for 1/2 inch pre-manufactured flexible metal conduit (FMC) whips from structure above. Whips shall not touch ceiling system as finally installed. Whips shall be kept 12 inches clear of ceiling except where required for termination at luminaires. Use of "fixture support wire installation" with caddy clip is permitted.
 5. Flexible metal conduit from junction box to luminaire shall not touch the ceiling as finally installed.
- D. Coordinate with other crafts to avoid conflicts between luminaires, supports, fittings and mechanical equipment.
- E. Surface Mounted Luminaires.
1. Mount with support rails attached to ceiling suspension support system, provided ceiling system has been certified to be suitable to support weight of luminaires.
 2. Where ceiling system has not been certified to support weight of luminaires, luminaires shall be supported at four points near each corner of luminaires.
 3. Provide a minimum 5/8" air space between the luminaires and the ceiling.
- F. Recessed Luminaires.
1. Handle specular/semi-specular louvers and down light cones using only new clean white cotton or silk gloves. Do not touch louvers or cones with bare hands. Leave luminaires clean and free of visible dust, debris, or fingerprints with lamps operational at time of acceptance of work.
 2. Recessed fluorescent luminaires in lay-in grid shall be supported independently from building structure above ceiling with galvanized steel wire at not less than 4 points near corners of luminaires. Size of wire shall be capable of supporting weight of luminaires. This requirement is separate and apart from hanger wire requirements of the ceiling grid.
 3. Recessed luminaire trims shall fit snugly to the mounting surface and shall not exhibit light leaks or gaps. Provide feed-through junction boxes or provide separate junction boxes. Components shall be accessible through the ceiling opening.
- G. Protect installed luminaires from damage during the remainder of the construction period.
- H. Luminaires must be completely wired and lamps installed. Luminaires must be operating properly at final completion.
- I. Adjustment.
1. Adjust luminaires to illuminate intended areas as directed.
 2. Adjust exterior luminaires during hours of darkness. Where acceptable to the Owner's Representative, exterior luminaires may be adjusted during daylight hours; verification of adjustments shall be conducted during hours of darkness.
- J. Upon completion of installation of interior luminaires, and after circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

- K. Immediately before final observation, clean luminaires, inside and out, including plastics and glassware, and adjust trim to properly fit adjacent surface, replace broken or damaged parts and lamp, and test luminaires for electrical as well as mechanical operation.
- L. Fluorescent lamps may be used in the final finishing of the building. Those lamps that have exceeded more than 10% of their rated life (as established by construction records), or that have darkened ends shall be replaced with new lamps before final acceptance.
- M. Linear and compact fluorescent lamps installed in luminaires with fluorescent dimming ballasts shall be "burned-in" at full brightness for 100 hours prior to dimming operation of lamps, and prior to final acceptance by Owner.
- N. Lamp Disposal. The procedure for disposal of lamps that contain mercury shall follow the guideline set by EPA (definitions in Title 40 Code of Federal Regulations 261 Subpart C, January 2000).
- O. At Owner's option, up to 30% of the fluorescent luminaires shall be opened by the Contractor for inspection. The luminaires may be inspected prior to or after installation. If instant-start ballasts are found, luminaires shall be opened, inspected and the instant start ballasts replaced with approved programmed rapid start ballasts at Contractor's expense.

3.4 TESTING

- A. The Contractor shall demonstrate to the Owner the proper operation of luminaires, systems and equipment specified in this Section and related Sections. The Contractor shall adjust, repair or replace as necessary components that do not perform as specified, until able to demonstrate proper operation of equipment in normal, automatic, manual, emergency, power-loss, and power-restored modes of operation, as applicable.

END OF SECTION

SECTION 28 31 00

FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of Division 1, General Requirements and other provisions of the contract documents apply to this work.
- B. This Section intends to describe an integrated fire detection and voice evacuation system with two way firefighters communications capabilities to be intelligent device addressable, analog detecting, low voltage and modular with multiplex communication techniques, in full compliance with all applicable codes and standards. The features described in this specification are a requirement for this project and shall be furnished by the successful contractor. Note that new fire alarm devices are being installed and connected to an existing system.
 - 1. The system as described shall be installed, tested, and delivered in full operating condition. The system shall include all required hardware, raceways, interconnecting wiring and software to accomplish the requirements of this specification whether itemized or not.
 - 2. All equipment furnished shall be new and the latest state of the art products of a single manufacturer, engaged in the manufacturing and sale of analog fire detection devices for over ten years. The equipment manufacturer shall have an installed base of analog systems as a reference. In the interest of job coordination, the installing contractor shall contract with a single source for supplying job materials, services, and programming, including final inspection/test services for the fire alarm system.
 - 3. The equipment, space requirements, expansion capabilities and features specified were selected to meet the requirement for this project. The fire alarm panel is existing and is a Siemens 4100. All new devices in the Penthouse shall connect to the existing system. Provide all new wiring, hardware, power supplies etc. as required for the new devices.
 - a. Existing Siemens 4100 System.

1.2 MATERIALS AND SERVICES

- A. The system shall include, but not be limited to the following elements:
 - 1. Power supplies, batteries and battery chargers.
 - 2. Equipment enclosures.
 - 3. Intelligent addressable manual pull stations, heat detectors, analog smoke detectors, alarm monitoring modules, and supervised control modules.
 - 4. Voice/Audible and visual evacuation signals.
 - 5. Software and firmware as required to provide a complete functioning system.
 - 6. Wiring and raceway.
 - 7. Installation, testing and certification and training.
 - 8. Interface with fan coil units.

1.3 REFERENCE STANDARDS

- A. The publications listed below form a part of this publication to the extent referenced. The publications are referenced in the text by the basic designation only. The latest version of each listed publication shall be used as a guide unless the authority having jurisdiction has adopted an earlier version.
1. Factory Mutual (FM). FM AG Approval Guide.
 2. National Fire Protection Association (NFPA).
 - a. NFPA 13 Standard for the Installation of Sprinkler Systems.
 - b. NFPA 25 Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems.
 - c. NFPA 70 National Electrical Code.
 - d. NFPA 72 Standard for the Installation, Maintenance and use of Protective Signaling Systems.
 - e. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems.
 - f. NFPA 101 - Life Safety Code.
 3. Underwriters' Laboratories, Inc. (UL).
 - a. Appropriate UL Standards.
 - b. UL FPED.
 4. Texas Department of Licensing and Regulation.
 5. Americans with Disabilities Act.
 6. International Building code and the respective fire code.

1.4 QUALIFICATIONS OF THE INSTALLER

- A. Before commencing work, submit data showing that the contractor has successfully installed fire alarm systems of the same type and design as specified, or that they have a firm contractual agreement with a subcontractor having the required manufacturers' training and experience. The contractor shall include the names and locations of at least two installations where the contractor, or the subcontractor above, has installed such systems. Specify the type and design for each system and furnish documentation that the system has performed satisfactorily for the preceding 18 months.

1.5 MANUFACTURER'S REPRESENTATIVE

- A. Provide the services of a representative or technician from the manufacturer of the system, experienced in the installation and operation of the type of system provided. The representative shall be licensed in the State of Texas. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the Owner's personnel in the system operation, maintenance and programming.

1.6 SUBMITTAL

- A. The contractor shall include the following information in the equipment submittal:
1. Power calculations.
 - a. Battery capacity calculations. Battery size shall be a minimum of 150% of the calculated requirement.
 - b. Supervisory power requirements for all equipment.
 - c. Alarm power requirements for all equipment.

- d. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst case condition.
 - e. Justification showing power requirements of the system amplifiers.
 - f. Voltage drop calculations for wiring runs demonstrating worst case condition.
 2. Complete manufacturer's catalog data including supervisory power usage, alarm power usage, physical dimensions, finish and mounting requirements.
 3. Submit panel configuration and interconnection of modules and all other data as required to make an informed judgment regarding product suitability. At a minimum, data shall be submitted on the following:
 - a. Power supplies, batteries and battery chargers.
 - b. Pre-amplifiers, amplifiers, tone generators, master microphone and master telephone.
 - c. Equipment enclosures, including dimensions and weights of completed units.
 - d. Intelligent addressable manual pull stations, heat detectors, analog smoke detectors, alarm monitoring modules, and supervised control modules.
 - e. Audible and visual evacuation signals and devices.
 - f. Software and firmware as required to provide a complete functioning system.
 - g. Circuiting, including conduit and wire sizes.
 4. Data describing more than one type of item shall be clearly marked to indicate the type the contractor intends to provide for options not crossed out in submittal material will be furnished for the project. All submittal material shall be complete. Partial submittal will not be evaluated and will be rejected without comment. The contractor shall submit copies of UL listing or FM approval data showing compatibility of the proposed device or appliance and the panel being provided.
 5. Complete drawings covering the following shall be submitted by the contractor for the proposed system:
 - a. Floor plans showing all new devices and connection to the existing system. Raceways shall be shown, marked for size, conductor count with type and size, showing the percentage of allowable National Electric Code fill used. Drawings shall indicate ambient sound levels used by the system installer for sound level calculations and mathematical justification for signal placement to meet the code required 15dBA above ambient for audible warning signals.
 - b. Wiring diagrams showing points of connection and terminals used for all electrical connections to the system devices and panels.
- B. For use in system test, a complete operation and maintenance manual with two sets of proposed installation drawings shall be submitted.
 1. The following information shall be inscribed on the cover:
 - a. "OPERATION AND MAINTENANCE MANUAL"
 - b. Building location.
 - c. The name of the contractor, system manufacturer and system subcontractor.
 - d. The name and phone number of the fire department required to respond to alarms at the project location.
 2. The manual shall be legible and easily read with large drawings folded and contained in pockets. Included in the manual shall be circuit drawings, wiring and control diagrams with data to explain detailed operation and control of each

item of equipment and a control sequence describing start up instructions. Included shall be installation instructions, maintenance instructions, safety precautions, test procedures, performance data, and software documentation.

- C. Upon completion of the installation, record drawings shall be submitted on each system before final acceptance of the work. The contractor shall furnish to the Owner a set of record drawings including system diagrams for each system. The record drawings masters shall be on reproducible mylar film, uniformly sized as required for legibility and reproduction and on high density floppy disks or CD ROM in an AutoCAD DXF format.

1.7 SYSTEM FUNCTION-EXISTING

- A. The existing system is a complete, electrically supervised multiplex style fire detection and voice evacuation system with intelligent analog alarm initiation, to be device addressable and annunciated as described. All new devices shall be of the same manufacturer as existing devices and shall be compatible with the existing system.

1.8 SYSTEM ZONING

- A. Each intelligent addressable device on the system shall be displayed at the fire alarm control panel by a unique alpha numeric label identifying its location.

1.9 SYSTEM OPERATION-EXISTING

- A. The new device operation shall match existing.

PART 2 - PRODUCTS

2.1 FIRE ALARM CONTROL PANEL - EXISTING

2.2 FIRE ALARM SYSTEM POWER SUPPLIES

- A. Provide additional power supplies as required to accommodate new devices in the Penthouse. Connect to circuit breaker in Panel PL.
- B. Secondary power supply. Provide sealed gelled electrolyte batteries as the secondary power supply for the fire alarm control panel and each system circuit interface panel. The battery supply shall be calculated to operate its load in a supervisory mode for twenty four hours with no primary power applied and, after that time, operate its alarm mode for two hours. Batteries shall be sized at no larger than 80% of the calculated size to compensate for deterioration and aging during the battery life cycle. Battery calculations shall be submitted to justify the battery size. Batteries shall be housed in the control cabinet or a separate cabinet with adequate cell separation to prevent accidental discharge.

2.3 DETECTOR BASES

- A. Detector Bases – Detector bases shall be low profile, surface or flush mounted in a standard 4" square by 2-1/8" deep box. Bases shall be able to accept photoelectric, ionization or heat detectors.

2.4 SMOKE DETECTORS-PHOTOELECTRIC

- A. Furnish and install intelligent analog smoke detectors with features and characteristics as follows:
1. Have an LED that flashed during normal operation.
 2. Be self adjusting for airborne contaminants.
 3. Have clear, distinct visual alarm indication.
 4. Be programmed to have alarm verification.

2.5 DUCT DETECTORS-PHOTOELECTRIC

- A. Furnish and install intelligent analog duct detectors with features and characteristics as follows:
1. Report to fire alarm panel as a supervisory alarm.
 2. Have clear, distinct visual power and alarm indications.
 3. Be programmed to have alarm verification.
 4. Have extended visual indicators if mounted above ceiling located as close to duct detector as possible.
 5. Install duct detectors in all supply and return ductwork/plenums. The exact quantity and location of detectors shall depend upon ductwork layout, size, installation etc. In general, a duct detector shall be located in a straight section of the supply air ductwork, a minimum of six duct widths downstream of the unit. If a minimum of six duct widths is not possible, a duct detector shall be located downstream of the main ductwork, in each section of ductwork that branches off from the main ductwork. For multi zone units the same rules apply and a duct detector shall be located in each duct section exiting the air handling unit. The exact location and quantity of duct detectors shall be based on the final installed ductwork configuration.

2.6 MANUAL STATIONS, INTELLIGENT

- A. Provide single action intelligent manual stations to be flush or surface mounted as required.
1. Shall be high impact plastic, red in color.
 2. Provide a clear indication when activated.
 3. Station shall be equipped with terminal strip and pressure style screw terminals for the connection of field wiring.
 4. The manual stations shall be addressable and identifiable by the master fire alarm control panel. Address assignments shall be set electronically and reside within the station in non-volatile memory. Devices using rotary switches, pins, jumpers or staples are not acceptable.
 5. Surface mounted stations shall be mounted using a manufacturer's prescribed matching baked red enamel outlet box.

2.7 INTELLIGENT SYSTEM INTERFACE MODULE

- A. Furnish and install, for the monitoring of contact type initiation devices and for the control of electrical devices where required, intelligent analog signaling circuit interface module. Modules shall be supplied to meet the project requirements as follows:
1. A single circuit intelligent signaling circuit interface module for monitoring alarm, trouble, supervisory security or status contact type devices.

2. Unit as above with form C software programmable control contacts for the management of specified electrical loads as required by this specification.
- B. The module shall be addressed, tested and programmed prior to installation using a UL listed programmer/tester.
- C. The module shall be suitable for two wire, two way communications on the intelligent analog signaling circuit. The module shall display a steady LED for each circuit, in the normal power or standby power condition, when in the alarm state or during control circuit activation.
- D. Modules shall incorporate triple technology microprocessor chips including analog, digital and EEROM technologies on the single device. Address assignments shall be set electronically and devices requiring dip switches, rotary switches, staples or jumpers are not acceptable.

2.8 INTELLIGENT SUPERVISED CONTROL MODULE

- A. Furnish and install for the control of supervised relays, contactors, audible signal circuits, visual signal circuits, distributed speaker circuits and two way fire fighters communication circuits, intelligent supervisory and control modules including features as follows:
 1. The modules shall be suitable for two wire operation and communications on intelligent analog alarm detection loops. Address assignments shall be accomplished electronically. Devices requiring dip switches, rotary switches, staples and/or jumpers are not acceptable.
 2. The module shall display a steady LED in the normal power or standby power condition, when in the activated state.
 3. The module shall be suitable for semi-flush or surface mounting in a 2" deep, 4" square or double gang electrical outlet box having a depth of 3 1/2".
- B. Modules shall be available to supervise reverse polarity supervised indicating circuits utilizing 24VDC, two way supervised fireman's communication circuits or audio circuits utilizing 25VRMS or 70.7VRMS. It shall be possible to configure the module for control of motor contactors and AC voltages to 115VAC.
 1. All connected field wiring shall be supervised for opens, short circuits and grounded circuits.
 2. All controlled circuits shall be power limited at 1.5A, produced by self restoring thermal components. Units requiring circuit replacement for restoration of outputs are not acceptable.
 - a. Signal outputs shall be supported in either Style "Y" or Style "Z" configuration.
 - b. The module shall report a trouble condition in the event of loss of the 24VDC signal operating supply voltage.

2.9 EVACUATION SIGNALS

- A. Speakers: Shall be of the polarized 24-Vdc type. Speaker shall be UL listed for fire alarm voice evacuation use. Speakers shall be designed to be mounted on a wall, ceiling or other suitable rigid surface and shall be capable of being surface, semi flush, or flush mounted. Speakers shall be multi-tap. Settings shall be 1/16, 1/8, 1/4, 1/2, 1, 2 or 4 watts.

- B. Strobe Light: ADA visual notification appliances shall be comprised of a xenon flashtube and be entirely solid state. These devices shall be UL listed and be capable of either ceiling or wall mounting. Provide a unit that is ADA compliant with an output no less than 15 candela. The Lexan lens shall be pyramidal in shape to allow better visibility. Provide a red lens on selected strobes where indicated on plans. Strobe light candela ratings have been shown on the plans. However, contractor is responsible for sizing strobes per NFPA 72 based on room size and device location. Units shall be installed 80" above finished floor. All strobes within the same line of site shall be synchronized. Candela ratings have been shown on the plans. These ratings shall be verified based on the room size and NFPA requirements. Where there are discrepancies The NFPA requirements for candela rating shall take precedence over the values shown on the plans. Provide multi-tap strobes to allow for a full range of candela settings. Settings shall be 15/75, 30/75, 75 or 110 candela. Circuits for strobes shall allow for capacity to increase strobe intensities one setting for all strobes. Provide spare devices equal to 1% of the total number of new devices provided for this project.
- C. Speaker/Strobe combination: Standard, ADA Audio/Visual units shall provide a common enclosure for the fire alarm audible and visual alarm devices. The housing shall be designed to accommodate either horns, bells, chimes or speakers. The unit shall be complete with a tamper resistant, Pyramidal shaped lexan lens with Fire lettering visible from a 180-degree field of view. The front panel or bezel that is constructed of UL Listed Noryl, may be inverted so that the lens is below the audible device. Integral Xenon strobe shall provide 8000 peak candlepower and be adjustable from 1 to 3 flashes per second. Provide a unit approved for ADA compliance. Strobe shall be multi-tap type to allow for a full range of candela settings as indicated in paragraph G. Xenon strobe shall provide 4-wire connection to insure properly supervised in/out system connection. Unit shall be complete with all mounting hardware including backbox. Audio/visual unit shall be UL listed for its intended purpose. Speaker shall be multi-tap type to allow for different audio settings as indicated in paragraph F. Provide spare devices equal to 1% of the total number of new devices provided for this project.
- D. The evacuation signals shall be available in flush, semi-flush, or surface versions as required for signal locations shown on the contract documents. Signals shall be mounted using a listed outlet box, and as required, tile bridges. Signals shall be available in visual only and combination to satisfy all required project applications. Visual only and combination audio/visual alarms shall be white with red "FIRE" lettering.

PART 3 - EXECUTION

3.1 DESIGN AND INSTALLATION DRAWINGS

- A. Show a general layout of the complete system including equipment arrangement. It shall be the responsibility of the fire alarm contractor to verify dimensions and assure compatibility with all other systems interfacing with the fire alarm system.
 - 1. Identify on the drawings, conduit and conductor sizes and types with number of conductors in each conduit. Provide each conduit and device with a unique identification. For addressable alarm initiation devices, the system identifier shall be the system address for that device. Signals shall be sequentially numbered as the address of the controlling module.
 - 2. Indicate on the point to point wiring diagrams, interconnecting wiring within the panel between modules, and connecting wiring to the field device terminals.
 - 3. Provide mounting details of FACP and other boxes to building structure, showing fastener type, sizes, material and embedded depth where applicable.

3.2 INSTALLATION

- A. Perform work in accordance with the requirements of NEC, NFPA 70, and NFPA 72.
- B. Fasten equipment to structural members of building or metal supports attached to structure, or to concrete surfaces.
 - 1. Use clamping devices for attaching to structural steel, or when clamping is impractical, obtain written authority to weld or to drill.
 - 2. Fasten equipment to concrete or masonry with expansion anchors.
 - 3. Fasten equipment to drywall by screws into studs, and to metal wall panels by weld studs, bolts or self tapping metal screws.
 - 4. Do not install conduit raceways and boxes in positions that interfere with the work of other trades.
 - 5. Attach nameplates on panels or other components as specified.

3.3 CONDUIT

- A. All wiring in exposed areas and where subject to damage shall be installed in conduit. Minimum conduit size shall be 3/4 inch. Plenum rated fire alarm wiring may be installed above lay-in ceilings. Provide a J-hook support system spaced at 5' on center and secured to the structure above.

3.4 BOXES, ENCLOSURES AND WIRING DEVICES

- A. Boxes shall be installed plumb and firmly in position.
 - 1. Extension rings with blank covers shall be installed on junction boxes where required.
 - 2. Junction boxes served by concealed conduit shall be flush mounted
 - 3. Upon initial installation, all wiring outlets, junction, pull and outlet boxes shall have dust covers installed. Dust covers shall not be removed until wiring installation when permanent dust covers or devices are installed.
 - 4. "Fire alarm system" decal or silk-screened label shall be applied to all junction box covers. All boxes shall be red.

3.5 CONDUCTORS

- A. Each conductor shall be identified as shown on the shop drawings with wire markers at every splice and terminal point. Attach permanent wire markers within 2 inches of each wire termination. Marker legends shall be visible.
 - 1. All wiring shall be supplied and installed in compliance with the requirements of the National Electric Code, NFPA 70, Article 760, and that of the manufacturer.
 - 2. Wiring for analog loop circuits and speaker circuits shall be 18 AWG twisted. Wiring for strobe circuits shall be a minimum 14 AWG.
 - 3. Splices shall be made using solderless connectors. All connectors shall be installed in conformance with the manufacturer's recommendations.
 - 4. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.
- B. Permanently label or mark each conductor at both ends with permanent alphanumeric wire markers.

- C. Provide Type CI, 2 hour rated circuit integrity cable or type MI cable for riser wiring and wherever else required per code.
- D. All wiring shall be installed in conduit.

3.6 CERTIFICATE OF COMPLIANCE

- A. Complete and submit to the Owner in accordance with NFPA 72.

3.7 FIELD QUALITY CONTROL

A. Testing, General.

1. All intelligent analog devices shall be tested and logged for correct address and sensitivity using test equipment specifically designed for that purpose. These devices and their bases shall be tagged with adhesive tags located in an area not visible when installed, showing the system address, initials of the installing technician and date.
2. Wiring runs shall be tested for continuity, short circuits and grounds before system is energized. Resistance, current and voltage readings shall be made as work progresses.
 - a. A systematic record shall be maintained of all readings using schedules or charts of tests and measurements. Areas shall be provided on the logging form for readings, dates and witnesses.
 - b. The acceptance inspector shall be notified before the start of the required tests. All items found at variance with the drawings or this specification during testing or inspection by the acceptance inspector, shall be corrected.
 - c. Test reports shall be delivered to the acceptance inspector as completed.
3. All test equipment, instruments, tools and labor required to conduct the system tests shall be made available by the installing contractor. The following equipment shall be a minimum for conducting the tests:
 - a. Ladders and scaffolds as required to access all installed equipment.
 - b. Multimeter for reading voltage, current and resistance.
 - c. Intelligent device programmer/tester.
 - d. Laptop computer with programming software for any required program revisions.
 - e. Two way radios, flashlights, smoke generation devices and supplies.
 - f. Spare printer paper.
 - g. A manufacturer recommended device for measuring air flow through air duct smoke detector sampling assemblies.
 - h. Decibel meter.
4. In addition to the testing specified to be performed by the installing contractor, the installation shall be subject to test by the acceptance inspector.
5. System wiring: fire alarm circuits shall be tested for continuity, grounds, and short circuits.

B. Acceptance testing.

1. A written acceptance test procedure (ATP) for testing the fire alarm system components and installation will be prepared by the Acceptance Inspector in accordance with NFPA 72, and this specification. The contractor shall be responsible for the performance of the ATP, demonstrating the function of the

- system and verifying the correct operation of all system components, circuits, and programming.
2. A program matrix shall be prepared by the installing contractor referencing each alarm input to every output function affected as a result of an alarm condition on that input. In the case of outputs programmed using more complex logic functions involving "any", "or", "not", "count", "time", and "timer" statements; the complete output equation shall be referenced in the matrix.
 3. A complete listing of all device labels for alpha numeric annunciator displays and logging printers shall be prepared by the installing contractor prior to the ATP.
 4. The acceptance inspector shall use the system record drawings in combination with the documents specified under Paragraph 3.1 during the testing procedure to verify operation as programmed. In conducting the ATP, the acceptance inspector shall request demonstration of any or all input and output functions. The items tested shall include but not be limited to the following:
 - a. System wiring shall be tested to demonstrate correct system response and correct subsequent system operation in the event of:
 - 1) Open, shorted and grounded intelligent analog signaling circuit.
 - 2) Open, shorted and grounded network signaling circuit.
 - 3) Open, shorted and grounded conventional zone circuits.
 - 4) Open, shorted and grounded speaker, telephone circuits.
 - 5) Intelligent device removal.
 - 6) Primary power or battery disconnected.
 - 7) Incorrect device at address.
 - 8) Printer trouble, off line or out of paper.
 - b. System evacuation alarm indicating appliances shall be demonstrated as follows:
 - 1) All alarm notification appliances actuate as programmed
 - 2) Audibility and visibility at required levels.
 - c. System indications shall be demonstrated as follows:
 - 1) Correct message display for each alarm input at the control panel, each remote alphanumeric display and each CRT terminal.
 - 2) Correct annunciator light for each alarm input at each annunciator and color graphic terminal as shown on the drawings.
 - 3) Correct printer logging for all system activity.
 - d. Secondary power capabilities shall be demonstrated as follows:
 - 1) System primary power shall be disconnected for a period of time as specified herein. At the end of that period, an alarm condition shall be created and the system shall perform as specified for a period as specified.
 - 2) System primary power shall be restored for forty-eight hours and system charging current shall be normal trickle charge for a fully charged battery bank.
 - 3) System battery voltages and charging currents shall be checked at the fire alarm control panel using the test codes and displayed on the LCD display.
 5. In the event of system failure to perform as specified and programmed during the ATP procedure, at the discretion of the acceptance inspector, the test shall be terminated.

- a. The installing contractor shall retest the system, correcting all deficiencies and providing test documentation to the acceptance inspector.
- b. In the event that software changes are required during the ATP, a utility program shall be furnished by the system manufacturer to compare the edited program with the original. This utility shall yield a printed list of the changes and all system functions, inputs and outputs effected by the changes. The items listed by this program shall be the minimum acceptable to be re-tested before calling for resumption of the ATP. The printed list and the printer log of the retesting shall be submitted before scheduling of the ATP.
- c. The acceptance inspector may elect to require the complete ATP to be performed again if, in his opinion, modifications to the system hardware or software warrant complete re-testing.

3.8 DOCUMENTATION

- A. System documentation shall be furnished to the owner and shall include but not be limited to the following:
 1. System record drawings and wiring details including one set of reproducible masters and drawings on CD ROM or DVD in a DXF format suitable for use in a CAD drafting program.
 2. System operation, installation and maintenance manuals
 3. Written documentation for all logic modules as programmed for system operation with a matrix showing interaction of all input signals with output commands.
 4. Documentation of system voltage, current and resistance readings taken during the installation, testing and ATP phases of the system installation.
 5. System program showing system functions, controls and labeling of equipment and devices. Also provide a 3.5" floppy or CD ROM diskette with system file.

3.9 TEST EQUIPMENT

- A. The Contractor shall furnish all test equipment as required to program devices and test the system, specifically an intelligent device tester and programmer.

3.10 WARRANTY AND SERVICES

- A. The contractor shall warrant the entire system against mechanical and electrical defects for a period of 18 months. This period shall begin upon completed certification and test of the system.
- B. During the warranty period, the fire alarm system subcontractor or manufacturer shall provide at no additional charge the inspection, parts, maintenance, testing and repair in full compliance with the requirements of NFPA 72.
- C. The installation contractor shall furnish training as follows for a minimum of four employees of the system user:
 1. Training in the receipt, handling and acknowledgement of alarms.
 2. Training in the system operation including manual control of output functions from the system control panel.
 3. Training in the testing of the system including logging of detector sensitivity, field test of devices and response to common troubles.

4. The total training requirement shall be a minimum of 6 hours but shall be sufficient to cover all items specified.

END OF SECTION