PROJECT MANUAL

Volume 2

Construct Bellefontaine Readiness Center

Bellefontaine Neighbors, Missouri

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STATE *of* MISSOURI

OFFICE *of* ADMINISTRATION
Facilities Management, Design & Construction

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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1.2 SUMMARY

A. This Section provides a comprehensive list of the drawings that comprise the Bid Documents for this project.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 LIST OF DRAWINGS

A. The following list of drawings is a part of the Bid Documents

	SHT	DRAWING NAME
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2	G001	DRAWING INDEX, ABBREVIATIONS, GENERAL NOTES, SYMBOLS
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31	C310	PERVIOUS PAVEMENT GRADING DETAILS
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34	C403	DRAINAGE PROFILES
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45	C414	DETENTION BASIN DETAIL - EAST BASIN
46	C415	DETENTION BASIN DETAIL - EAST BASIN
47	C416	DETENTION BASIN DETAIL - WEST BASIN
48	C417	DETENTION BASIN DETAIL - WEST BASIN
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END OF SECTION 00 01 15

SECTION 23 01 00
BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01:
   1. Submittals.
   2. Material and Equipment Selection.
   3. Record documents.
   4. Maintenance manuals.
   5. Construction IAQ Management Plan.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 23.

1.03 CONTRACTOR'S SUBMITTAL RESPONSIBILITIES

A. General: Follow the procedures specified in Division 01. In addition to the requirements specified in Division 01, comply with the following:
   1. Increase by two (2) the quantity of print copies required by Division 01 for submittals, if paper submittals are used. (Paperless electronic submittals are preferred.)
   2. Electronic Submittals: Prepare submittals as PDF package, incorporating complete information into each PDF file. Name PDF file with submittal number. Transmit via email. Include PDF transmittal form. Include information in email subject line as to project name, project number, submittal number, and applicable specification section number.
   3. Submit line-by-line specification verification for equipment other than the "basis of design" as further described in the following article "Material and Equipment Selection".

B. General: Submittals are not requested for all products covered in the specifications. Submit only the data requested under the submittals portion of each specification section or where indicated in a Submittal Log, if included within Division 01. Un-requested submittals will not be processed, reviewed or returned and the contractor will be notified that the submittal will not be reviewed by the engineer of record.
   1. Non-requirement of submittals, when so noted, is not to be construed as an allowance for substitutions and does not relieve the contractor from full compliance with the plans and specifications.
   2. Any deviation from specified items is considered a substitution. If the contractor desires to use other than specified items, then a formal request for substitution must be submitted prior to bid date (no exceptions), in accordance with the procedures and time limitations set forth in Division 01. Where not defined in Division 01, requests for substitutions shall be submitted no less than ten (10) working days prior to bid date. Review of substitution requests by the Engineer shall be done at the expense of the contractor. Charges for this substitution review shall be calculated based on the Engineer's standard hourly rates, as defined in their contract with the Owner.

C. It is the responsibility of the Contractor to ensure that all submittals have been reviewed for total completeness and accuracy as to the requirements of the specifications and drawings before being submitted to the Engineer for review.
   1. One comprehensive submittal shall be provided for each individual specification section. All required submittal information called for in each individual specification section shall be included in the submittal.

2. The Engineer of Record shall not be responsible for informing the contractor on items that have not been included and are necessary for a complete review of the required submittal information for a specification section.
3. The Engineer of Record shall have the option of returning any submittal, unmarked, if all required documentation called for in the specifications has not been provided in the submittal.
4. The Engineer of Record shall review each submittal no more than two (2) times and return to the contractor with the appropriate disposition.
5. If the Engineer of Record is required to review a submittal a second time, it shall be limited to review of the changed information, clearly highlighted by the submitter, and/or confirmation of documentation only and it shall be returned to the contractor with the appropriate disposition.
6. If the submittal is required to be reviewed a third time, it shall be done at the expense of the contractor. Charges for this additional submittal review shall be calculated based on the Engineer's standard hourly rates, as defined in their contract with the Owner.

D. Operation and Maintenance Manuals: All items required for insertion into each Operation and Maintenance (O&M) Manual are called out in the submittals portion of each specification section or in a Submittal Log, if included within Division 01. It is the responsibility of the Contractor to ensure that the O&M submittal has been reviewed and includes all the requirements of the specifications. The Engineer of Record shall review the submittal for the Operation and Maintenance Manual one (1) time and return to the contractor with the appropriate disposition.
1. If the submittal is required to be reviewed a second time, it shall be done at the expense of the contractor. Charges for this additional submittal review shall be calculated based on the Engineer's standard hourly rates, as defined in their contract with the Owner.
2. Submittals for the Operation and Maintenance Manual must be original documentation.
3. Photo copies of marked up Operations and Maintenance submittals are not acceptable.

E. Refer to Division 01 and each individual Division 23 Section for additional submittal requirements.

1.04 DEFINITIONS

A. LEED-NC: Leadership in Energy and Environmental Design for New Construction, as defined by the United States Green Building Council.

1.05 REFERENCED STANDARDS

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Guideline 4-2008 (RA 2013) *Preparation of Operating and Maintenance Documentation for Building Systems*. Atlanta, GA: ASHRAE, 1993.

B. Sheet Metal and Air Conditioning Contractors' National Association. *IAQ Guidelines for Occupied Buildings Under Construction*. Chapter 3. Chantilly, VA: SMACNA, 1995.

C. United Facilities Criteria (UFC) 4-010-01. *DoD Minimum Antiterrorism Standards for Buildings*. United States Corps of Engineers Protective Design Center. Omaha, NE: December 12, 2018.

D. United Facilities Criteria (UFC) 4-510-01. *Design: Medical Military Facilities*. United States Corps of Engineers: May 30, 2019, Including Change 1, June 21, 2019.

1.06 BUY AMERICAN ACT

A. The Contractor shall use only domestic construction materials and components in performing under these specifications in accordance with the Buy American Act (41 USC 10a-10d), or shall submit waivers for same as permitted thereunder.

B. Each material or component must be manufactured in the United States and the cost of the domestic sub-components must exceed 50% of the cost of all the components unless one or more exceptions apply under the Buy American Act.

C. Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product's shop drawing submittal.

D. See Division 1 front-end specifications for additional information on Buy American.

1.07 MATERIAL AND EQUIPMENT SELECTION

A. Product Options: The specification of each item of major mechanical equipment required for the project may include a list of manufacturers, with one "basis of design" manufacturer, type, and model identified by virtue of their listing in the equipment schedule on the Drawings. Where several manufacturers in addition to the "basis of design" manufacturer are listed in the specifications, it shall be understood that the words "or approved equal by" are implied to precede each of the other manufacturer's names.

1. The manufacturers other than the "basis of design" may be furnished at the contractor's option in lieu of the "basis of design" product, provided that the selected manufacturer's product is equal in all material and functional respects. In addition to submittal requirements that may be specified in this section, submit a line-by-line written verification of the applicable specification section(s) identifying compliance with or variations from the specified features, materials, performance, capacities, weight, size, durability, energy consumption and efficiency, warranty, and visual impact (if exposed to view by other than maintenance persons). The burden of proof of manufacturer/product equality is on the contractor.
2. Where a product is not scheduled on the drawings and, therefore, where no "basis of design" is indicated, selection among all of the listed manufacturers and products is at the contractor's option, subject to the requirements of the Contract Documents.
3. Products of manufacturers not listed in the Contract Documents are considered Substitutions and are not permitted, except as provided under the General and Supplementary Conditions and Division 01 Specifications. Full compliance with Division 01 section "Product Substitutions" is mandatory for acceptance of products or manufacturers not listed.

B. Listing of a manufacturer does not imply approval of that manufacturer's standard product or products. Rather, listing of a manufacturer indicates only a general acceptance of that manufacturer's name and reputation. Final approval is subject to full compliance with these Contract Documents.

C. Model numbers identified on the Drawings notwithstanding, all equipment must comply with the requirements of these Contract Documents. Do not assume that a manufacturer's standard product is acceptable as is. For example, one or more custom modifications, custom colors or finishes, manufacturer's options, and/or accessories may be required to meet the specified requirements.

D. Where drawings indicate sizes, profiles, connections, and dimensional requirements of material and equipment, these are based on the "basis of design" manufacturer, type and model indicated. In the event that equipment of power, dimensions, capacities, layout, connections, and/or ratings differing from the "basis of design" are selected by the contractor and approved by the Owner's representative, any necessary adjustments are the contractor's responsibility. All connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, pipe and duct sizes, pipe and duct layout, and the like shall be adjusted by the contractor to suit the equipment provided. No additional costs will be approved for these changes. Should revisions to the design because of contractor's selection of manufacturer, type, or model other than the "basis of design" require additional review and/or redesign by an Architect or Engineer, the contractor shall reimburse the Owner for Owner's added professional fee expenses.

E. Where two or more materials are listed in the "Part 2 – Products" subsection of any Division 23 section, do not assume that the selection of materials is the contractor's option. Refer to "Part 3

– Execution" subsection of that same Division 23 section for an explanation of which specific material(s) shall be used for which specific application(s). For example, Part 2 may list several types and grades of piping, and Part 3 will describe which type and grade of pipe to use for a given application.

F. Electronic media files of the contract drawings in AutoCAD or PDF format and copies of the specifications in PDF format may be requested.

G. Complete and return a signed "Electronic File Transmittal" form provided by Introba upon request for electronic media.

H. Obtain approval from the appropriate Design Professional for use of their part of the documents if the information requested includes information prepared by other than Introba.

I. The electronic contract documents may be used for preparation of shop drawings and record drawings only. The information may not be used in whole or in part for any other project.

J. The drawings prepared by Introba for bidding purposes may not be used directly for raceway layout drawings.

K. The use of these documents does not allow relief from the responsibility for coordination of work with other trades and verification of space available for the installation.

L. The information is provided to expedite the project with no guarantee by Introba as to the accuracy or correctness of the information provided. Introba accepts no responsibility or liability for the use of the provided information.

1.08 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 01. In addition to the requirements specified in Division 01, indicate the following installed conditions:
   1. Ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.
   2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Indicate actual inverts and horizontal locations of all underground piping.
   3. Valve location diagrams, complete with valve tag chart. Refer to Division 23 Section "Basic Mechanical Materials and Methods."
   4. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
   5. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.09 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01. In addition to the requirements specified in Division 01, include the following information for equipment items:
   1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Servicing instructions and lubrication charts and schedules.

5. Facsimiles or photo copies are not allowed as submittals for operating and maintenance manuals. Submittals for operating and maintenance manuals must be on original manufacturer printed stock.

B. In addition to the above, comply with ASHRAE Guideline 4-2008 (RA 2013) *Preparation of Operating and Maintenance Documentation for Building Systems*.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. During construction, meet or exceed the recommended Design Approaches of SMACNA *IAQ Guideline for Occupied Buildings under Construction*.

B. Protect stored on-site or installed absorptive materials from moisture damage. Materials directly exposed to moisture via precipitation, water leaks, or condensation shall be removed from the jobsite and replaced.

3.02 CONSTRUCTION IAQ MANAGEMENT

A. General Intent: Perform Construction IAQ Management as further described herein, as required to achieve LEED-NCv4 Credit EQc3 for “Construction Indoor Air Quality Management Plan.”

B. Temporary Ventilation: The contractor shall provide temporary ductwork and fan systems to exhaust the construction areas, providing negative pressures in relation to adjacent non-construction (occupied) areas, of 0.05-inch w.c. adjustable. This exhaust ductwork shall be routed through openings to the exterior, such as windows, and discharged at a location 25-feet or more removed from pedestrian walkways, roadways, other air intakes, doors, or windows serving occupied areas. The temporary exhaust fan(s) shall be installed in a draw-through arrangement to limit air leakage downstream of the fans back into the space(s).

1. Temporary exhaust fans shall be sized for approximately 0.5 cfm per square foot of construction zone served.
2. All ductwork shall be of galvanized construction, furnished and installed per Division 23 Section “Metal Ducts” and sealed per Seal Class A.

C. Construction Zone Pressure Monitoring: Provide monitor consisting of a transmitter module and two sensing probes with stainless steel trim plates. Mount reference probe in an adjacent, non-construction zone hallway, six inches above the floor, and construction zone probe six inches above the floor in the construction zone near the main entry into the construction zone. Transmitter module, powered by 24 VAC, shall be microprocessor based and include an air velocity sensor, 4-20ma analog output, SPDT alarm relay output, and RS-485 digital communications link. Flow measurement accuracy over the range selected shall be plus or minus 10 feet per minute and a resolution of one foot per minute; pressure measurement accuracy over the selected range shall be one percent of the set span with resolution of 0.001-inches of water column or better. Subject to compliance with specifications, example of acceptable device is Model SPM-5100 by Tek-Air Systems, Inc. or approved equal

1. Construction Zone Alarm Status Display: A wall-mounted display module with LED display and audible alarm horn and mute (acknowledge) button. Display module shall mount on a standard 4-inch by 4-inch electrical box, with tamper-proof screws.
2. Provide a transformer as required for low voltage control power.

D. If permanent building ductwork and air handling equipment are used for temporary ventilation during construction, filtration media with a MERV-8 or better shall be used at each and every return air opening for the duration of operation. Refer to Division 23 Section “Air Filters” for filter requirements.

1. Shut down or damper-off the return side of the HVAC system in areas of heavy construction or demolition. Seal return system openings with plastic where major activity occurs.
2. Repair all leaks in ducts and air handling equipment promptly.

3. Erect temporary barriers between work areas and non-work areas.
4. Provide and operate temporary ventilation to maintain slightly negative air pressurization in heavy work areas, to minimize tendency of dust, debris, and contaminants from migrating to non-work areas.

E. Building Flush-Out: After construction ends but prior to occupancy, conduct a minimum two-week building flush-out using permanent building ductwork and air handling equipment. Flush-out shall be made with 100% outdoor air and MERV-13 or better filtration media. If extremes of cold, hot, or humid weather are anticipated during flush-out, participate with design professional in formulating a climate control plan.

F. Replace all filtration media immediately prior to occupancy, using MERV-13 or better filtration media. Refer to Division 23 Section “Air Filters” for filter requirements.

G. Document Construction IAQ Management activities. Such documentation shall include, as a minimum:
1. List each air filter used during construction. Include the MERV value, manufacturer name and model number, and a designation of where used on this project.
2. List each air filter installed at the end of construction. Include the MERV value, manufacturer name and model number, and a designation of where used on this project.
3. Provide 18 photographs (six photographs taken on three different occasions during construction), along with identification of the SMACNA approach featured by each photograph, in order to show consistent adherence to the SMACNA Guideline.

END OF SECTION

SECTION 23 05 00
BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following basic mechanical materials and methods to complement other Division 23 Sections:
   1. Materials and installation instructions common to mechanical systems.
   2. Pipe joining materials and methods.
   3. Pipe sleeves.
   4. Penetration firestopping of fire-resistance-rated assemblies by mechanical piping, conduit, or ductwork.
   5. Labeling and identifying mechanical systems and equipment.
   6. Non-shrink grout for equipment installations.
   7. Painting and finishing of mechanical work.
   8. Coordination with Structural work.
   9. Field-fabricated equipment supports.
   10. Cutting and patching.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints” and Section 23 01 00 “Basic Mechanical Requirements” apply / applies to the work of this Section as if fully repeated herein.

C. Pipe and pipe fitting materials are specified in individual Division 23 piping system Sections.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, 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 in duct shafts.

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. The following abbreviations are used throughout Division 23 Specification Sections:
   1. ABS: Acrylonitrile-butadiene-styrene plastic.
   2. CPVC: Chlorinated polyvinyl chloride plastic.
   3. CR: Chlorosulfonated polyethylene synthetic rubber.
   4. EPDM: Ethylene propylene diene terpolymer rubber.
   5. NBR: Acrylonitrile-butadiene rubber.
   6. NP: Nylon plastic.
   7. PE: Polyethylene plastic.
   8. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

A. Product Data: For identification materials and devices.

B. Shop Drawings: Detail fabrication and installation for supports and anchorage for mechanical materials and equipment.

C. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.05 QUALITY ASSURANCE

A. Welding: Qualify welding processes and operators for structural steel according to AWS D1.1 “Structural Welding Code – Steel.”

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and prevent entrance of dirt, debris, and moisture. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor or roof, if stored thereupon. Protect fittings and piping specialties from moisture and dirt.

B. Protect ductwork interiors from the elements and foreign materials throughout construction. Deliver ducts with shop-applied impervious protective covering over all open ends. Maintain protective end coverings through shipping, storage, and handling to prevent entrance of dirt, debris, and moisture. Elevate stored ducts above grade. As ductwork is installed, remove protective end covering as each successive segment is connected, but with protective end covering maintained over open ends remaining exposed.

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

1.07 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

C. Coordinate installation of required supporting devices and set sleeves in structural components, as they are constructed.

D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

E. Coordinate requirements for access panels and doors if mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section “Access Doors and Panels.”

F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Coordinate connection of electrical services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Identifying Devices and Labels:
   a. Brady USA, Inc., Signmark Div.
   b. Brimar Industries, Inc.
   c. Kolbi Industries, Inc.
   d. Panduit Corp.
   e. Seton Name Plate Co.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section "Basic Mechanical Requirements." Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product's shop drawing submittal.

2.02 PIPE AND PIPE FITTINGS

A. Refer to individual Division 23 piping Sections for pipe and fitting materials and joining methods.

2.03 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Solder Filler Metals: ASTM B32 lead-free alloys. Include water-flushable flux according to ASTM B813.

2.04 PIPE SLEEVES

A. The following sleeve materials are for wall, floor, slab, and roof penetrations.

B. Steel Pipe: ASTM A53, Type E, Grade A, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. PE: Manufactured, reusable, tapered, cup shaped, smooth outer surface, with nailing flange for attaching to wooden forms.

E. Contractor's Option: Pre-engineered, UL-listed fire-resistance rated and watertight cast-in-place floor sleeving systems meeting the following specifications will be acceptable in lieu of traditional floor sleeves with field-installed firestop, at contractor's option.
   1. Description: Cast-in-place, factory-assembled, one-piece watertight firestop device for use in concrete floors formed with wood and/or steel decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke, fire, and hot gasses.
   2. Manufacturer: Subject to compliance with requirements, provide Hydroflame™ sleeving system by Hubbard Enterprises / Holdrite; or approved equal.
   3. Include an outer sleeve lined with an intumescent strip; and a radial extended flange attached to one end of the sleeve for fastening to concrete formwork; or wide outside wings attached to one end of the sleeve for fastening to metal deck concrete formwork and span deck corrugations.
   4. Include a waterstop gasket and mid-body seal consisting of one to three concentric raised rings for embedment and sealing to the concrete slab. For applications involving a corrugated deck, also include a cone attached to the base for extending the device through the metal deck.
   5. Product shall provide a two-hour fire-resistance rated assembly when tested according to ASTM E814 or ANSI/UL 1479.

2.05 IDENTIFYING DEVICES AND LABELS

A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 23 Sections. If more than one type is specified for application, selection is installer's option, but provide one selection for each product category.

B. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

C. Equipment Nameplates: Metal nameplate with operational data engraved or stamped; permanently fastened to equipment; furnished and factory-installed by original equipment manufacturer.
   1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.
   2. Location: Accessible and visible location.

D. Plastic Duct Markers: Manufacturer's standard color-coded, laminated plastic. Comply with the following color code:
   1. Green: Cold air.
   2. Yellow: Hot air.
   3. Yellow/Green or Green: Supply air.
   4. Blue: Exhaust, outside, return, and mixed air.
   5. For hazardous exhausts, use colors and designs recommended by ASME A13.1.
   6. Nomenclature: Include direction of airflow and duct service.
   7. Example: ←RETURN AIR←

E. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated.
   1. Fabricate in sizes required for message.
   2. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
   3. Punch for mechanical fastening.
   4. Thickness: 1/16-inch (1.6 mm), for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) long; 1/8-inch (3.2 mm) for larger units.
   5. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.

F. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.
   1. Multiple Systems: If multiple systems of same generic name are indicated, provide identification that indicates individual system number and service such as "Boiler No. 3," "Air Supply No. 1H," or "Standpipe F12."

2.06 CONCRETE AND GROUT

A. Concrete: For all minor concrete work required for mechanical installations, such as concrete supports, refer to Division 03 Sections for specification of cast-in-place concrete and reinforcing materials, whose requirements apply to the work of Division 23 as if fully reproduced herein.

2.07 PAINTING AND FINISHING

A. For all painting and finishing work required for mechanical installations, as described in Part 3 of this Section and/or on the Drawings, refer to Division 09 Sections for specification of paint and finishing materials, whose requirements apply to the work of Division 23 as if fully reproduced herein.

PART 3 - EXECUTION

3.01 GENERAL MECHANICAL INSTALLATION REQUIREMENTS

A. Verify all dimensions by field measurements.

B. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

C. Install systems, materials, and equipment to conform with approved submittal data to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

D. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

E. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

F. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.02 PIPING SYSTEM INSTALLATION REQUIREMENTS

A. General: Install piping as described below, unless piping Sections specify otherwise. Individual Division 23 piping Sections specify unique piping installation requirements.

B. General Locations and Arrangements: 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.

C. Install components with pressure rating equal to or greater than system operating pressure.

D. Install piping at indicated slope, and free of sags and bends.

E. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal. Install piping to allow application of insulation plus 1-inch (25-mm) clearance around insulation.

F. Install fittings for changes in direction and branch connections. Install couplings according to manufacturer’s written instructions.

G. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

H. Electrical Equipment Spaces: Route piping to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

I. Piping Support: As specified in Division 23 Section “Hangers and Supports.”

3.03 PIPING JOINING REQUIREMENTS

A. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping specification Sections.

B. Ream ends of pipes and tubes and remove burrs.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

E. Piping Connections: Make connections according to the following, unless otherwise indicated.
   1. Install unions, in piping 2-inch NPS (DN50) and smaller at final connection to each piece of equipment with 2-inch NPS (DN50) or smaller threaded pipe connection.

3.04 PIPE-PENETRATION INSTALLATION REQUIREMENTS

A. Install sleeves for pipes passing through concrete and masonry walls.

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

C. Fire-Resistance Rated, Cast-in-Place Sleeve Installation: Select sleeve size based on size and type of pipe and thickness of the floor. Position and secure sleeve to concrete form using nails or staples. Place concrete and finish even with top of sleeve. Install in complete and strict accordance with manufacturer's UL-listed installation instructions.

D. Build sleeves into new walls and slabs as work progresses.

E. Install sleeves large enough to provide ¼-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   1. Steel Pipe Sleeves: For pipes smaller than 6-inch NPS (DN150).
   2. Seal space outside of sleeve fittings with non-shrink, non-metallic grout.

F. Seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants. Refer to Division 07 Section "Joint Sealants" for materials. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated.

G. Aboveground, Exterior-Wall, Pipe Penetrations: Seal penetrations using sleeves. Size sleeve for 1-inch (25-mm) annular clear space between pipe and sleeve.
   1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) in diameter and larger.

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

I. Permanent sleeves are not required for holes formed by PE removable sleeves.

J. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

3.05 EQUIPMENT INSTALLATION REQUIREMENTS

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to equipment specifications in Division 23 and Division 26 for rough-in requirements.

B. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

C. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect.

D. Positive attachment and anchorage of all equipment to the structure or floor is required. Do not rely on friction or gravity as a means of attachment.

E. Support for Suspended Equipment: As specified in Division 23 Section "Hangers and Supports."

3.06 LABELING AND IDENTIFYING

A. Equipment: Install engraved plastic-laminate sign on or near each major item of mechanical equipment.

1. Lettering Size: Minimum ¼-inch- (6.4-mm-) high lettering for name of unit if viewing distance is less than 24 inches (610 mm), ½-inch- (12.7-mm-) high lettering for distances up to 72 inches (1800 mm), and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish between multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

B. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers showing duct system service and direction of flow. In each space, if ducts are exposed or concealed by removable ceiling system, locate signs near points where ducts enter into space and at maximum intervals of 50 feet (15 m).

C. Adjusting: Relocate identifying devices as necessary for unobstructed view in finished construction.

3.07 PAINTING AND FINISHING

A. For all painting and finishing work required for mechanical installations, refer to Division 09 Sections for application requirements.

B. Painting HVAC Work: Paint the following work where exposed to view in finished or unfinished spaces: Uninsulated steel piping, pipe hangers and supports, tanks that do not have factory-applied final finishes, all interior and exterior ferrous piping and appurtenances, including steel, galvanized steel, cast iron and ductile iron.

3.08 COORDINATION WITH STRUCTURAL WORK

A. Concrete: Do not embed pipes, wires, tube, boxes, ducts or other cavity-creating elements in concrete work unless shown on or permitted by the structural drawings. Openings through concrete not shown on the structural drawings are subject to approval by the structural engineer of record.

B. Roof Deck: Do not place loads on, or hang any loads whatsoever from roof deck, unless shown on structural drawings, including, but not limited to, hangers for pipes, ducts, equipment, etc. Trade contractor installing such loads shall provide sub-framing connected to steel frame.
1. Do not exceed capacity of roof deck as a working platform. Submit all proposed construction loads to deck supplier for approval.
2. Openings in roof deck not shown on structural drawings, such as openings required for stacks, pipes, ducts, plumbing vents, etc., shall be cut and reinforced by trade requiring opening.

C. Supported Slab: Do not suspend loads exceeding 500 pounds within any 100 square feet of contiguous area from concrete supported slab. Suspend such loads from structural steel only. Any “sub-framing” required is responsibility of Contractor or sub-contractor installing material requiring support.
1. Openings in concrete floor slabs not shown on structural drawings, such as openings required for stacks, pipes, ducts, plumbing vents, etc., shall be the responsibility of the trade requiring openings. Form blockouts in the slab, reinforcing deck, and cut openings after concrete has reached specified strength.
2. Where openings larger than 12-inches are required but not shown on structural drawings, secure written approval from Architect/Engineer prior to cutting deck.

3.09 ERECTION OF SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1, “Structural Welding Code – Steel.”

3.10 CUTTING AND PATCHING

A. General: Employ skilled workmen to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time and complete without delay. Perform cutting and patching in accordance with the following:

B. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

C. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
   1. Uncover Work to provide for installation of ill-timed Work.
   2. Remove and replace defective Work.
   3. Remove and replace Work not conforming to requirements of the Contract Documents.
   4. Install equipment and materials in existing structures.

D. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, pumps, and other mechanical items made obsolete by the new Work.

E. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.

F. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

G. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

H. Repair cut surfaces to match adjacent installations.

I. Repair any building insulation or building fireproofing materials, whether new or existing, that are removed or scraped away in order to make a mechanical installation, so as to maintain an equivalent insulation or fire rating as existed without said mechanical installation.

J. Refer to Division 01 Sections “Execution” and/or “Cutting and Patching” for additional requirements.

END OF SECTION

SECTION 23 05 13
MOTORS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes basic requirements for factory-installed motors associated with mechanical equipment specified elsewhere in Division 23.

B. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 "Seismic Restraints," Section 23 01 00 "Basic Mechanical Requirements," and Section 23 05 00 "Basic Mechanical Materials and Methods" all apply to the work of this Section as if fully repeated herein.

C. Related Sections include all other Division 23 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.03 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. ECM: Electrically-commutated motor.

C. ODP: Open drip-proof.

D. TEAO: Totally-enclosed, air-over.

E. TEFC: Totally-enclosed, fan-cooled.

1.04 SUBMITTALS

A. Product Data: Submit motor product data with each associated equipment submittal. Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lug; and coatings.

B. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section "Basic Mechanical Requirements."

1.05 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. UL Listing: Motors specified in this Section must be listed and labeled by Underwriters Laboratories and bear the UL logo.

1.06 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:
   1. Compatible with magnetic controllers, multi-speed controllers, and/or reduced-voltage controllers where applicable.
   2. Designed and labeled for use with variable frequency controllers where applicable and suitable for use throughout speed range without overheating.

3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide motors by one of the following:
1. Baldor Electric Co.
2. Century Electric Co.
3. General Electric Co.
4. MagneTek
5. Marathon Electric Mfg. Co.
6. Reliance Electric Co.
7. Siemens Energy & Automation, Inc.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 BASIC MOTOR REQUIREMENTS

A. Basic requirements apply to all types of mechanical equipment motors, unless otherwise indicated.
1. Motors ½ HP and Larger: Polyphase.
2. Motors Smaller than ½ HP: Single phase.
3. Frequency Rating: 60 Hz.

B. Voltage Rating: NEMA standard voltage selected to operate on nominal voltage of circuit to which motor is connected.

C. Service Factor: According to NEMA MG 1, unless otherwise indicated, but at least 1.15 polyphase motors and 1.35 for single-phase motors.

D. Duty: Continuous duty at ambient temperature of 104°F (40°C) and at altitude of 3300 feet (1000 meters) above sea level.

E. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

F. Enclosure: ODP, unless otherwise indicated.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design E, medium induction motor, unless otherwise indicated.
1. Stator: Copper windings, unless otherwise indicated.
2. Rotor: Random-wound, squirrel cage, unless otherwise indicated.
3. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
4. Temperature Rise: Match insulation rating, unless otherwise indicated.
5. Insulation: Class F, unless otherwise indicated.

B. Code Letter Designation: Motors 15 HP and larger shall be NEMA starting Code F or Code G. Motors under 15 HP shall have manufacturer's standard starting characteristics.

C. Enclosure: Cast iron for motors 7½ HP and larger; rolled steel for motors smaller than 7½ HP; with enamel finish.

D. Efficiency: Motor efficiencies for motors one horsepower and greater shall in no case shall be less efficient than "Premium Efficiency" as defined in NEMA MG 1-2014 *Motors and Generators*. Motors shall be tested and labeled in accordance with NEMA MG 1-2014 Standard. Motor nameplate labeling shall include both the minimum and nominal efficiency.

E. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

F. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Designed with critical vibration frequencies outside operating range of controller output.
   2. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   3. Temperature Rise: Matched to rating for Class B insulation.
   4. Insulation: Class F or H.
   5. Motor shall be inverter-duty or inverter-ready and shall not require the use of external cooling fans.

G. Shaft Grounding Ring: On any and all motors to be controlled by a Variable Frequency Motor Controller, include an engineered ring consisting of two or more rows of circumferential conductive microfibers to redirect shaft current and provide a low-impedance path from shaft to frame, bypassing the motor bearings. Factory-install on the motor shaft by sliding the ring over either end, and lock it in place with mechanically-fastened mounting brackets. Motors over 100 nameplate horsepower shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Product shall be "Aegis SGR" by Electro Static Technology or approved equal.

H. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

I. Source Quality Control: Perform the following routine tests according to NEMA MG 1:
   1. Measurement of winding resistance.
   2. No-load readings of current and speed at rated voltage and frequency.
   3. Locked rotor current at rated frequency.
   4. High-potential test.
   5. Alignment.

2.04 SINGLE-PHASE MOTORS

A. Type: As indicated or selected by manufacturer from one of the following, to suit starting torque and other requirements of specific motor application.
   1. Permanent-split capacitor.
   2. Split-phase start, capacitor run.
   3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: Do not use, unless motors are smaller than 1/20 hp.

C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

D. Thermal Protection: Where indicated or required, internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to

temperature rating of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

E. Bearings: Ball-bearing type for belt-connected motors and other motors with high radial forces on motor shaft. Sealed, pre-lubricated sleeve bearings for other single-phase motors.

2.05 ELECTRICALLY-COMMUTATED MOTORS

A. General: Electrically-Commutated Motors are required wherever indicated in other Division 23 Specifications and/or notations on the Drawings.

B. Motor: Motor shall be ECM, variable-speed, DC type, brushless motor designed for fan applications with heavy duty permanently lubricated ball bearings and electric commutation. It shall contain internal circuitry that converts single phase power into a DC signal. Motor shall be designed for direct-drive applications.

C. Speed Control: The ECM shall be speed-controllable down to 10% of full speed via exterior-mounted field-adjustable potentiometer dial or DDC control signal input.

D. Efficiency: Minimum 70% at all speeds.

E. Voltage: Single-phase 115-V, 208-V, or 277-V as indicated.

F. Rotor: Synchronous; permanent magnet type; built-in soft start.

G. Thermal Protection: Where indicated or required, internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

PART 3 - EXECUTION

3.01 INSTALLATION, ALL MOTORS

A. Use adjustable motor mounting bases for belt-driven motors. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer’s written instructions. Verify bearing lubrication.

B. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load. Test interlocks and control and safety features for proper operation. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

C. Correct malfunctioning motors on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new motors and retest.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment, including but not limited to the following:
   1. Metal pipe hangers and supports.
   2. Metal framing systems.
   3. Thermal-hanger shield inserts.
   4. Fastener systems.
   5. Pipe stands.
   6. Equipment stands.
   7. Equipment supports.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 "Seismic Restraints."," Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 13 Section “Seismic Restraints” for seismic restraint requirements.
   2. Division 21 Section “Standpipe and Sprinkler Systems” for fire-suppression pipe hangers.
   3. Division 23 Section “Mechanical Vibration Isolation” for vibration isolation devices.
   4. Division 23 Section “Metal Ducts” for duct hangers and supports.

1.03 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

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

1.04 PERFORMANCE REQUIREMENTS

A. If contractor elects to apply channel support systems to support multiple pipes, in lieu of individual supports, then contractor is responsible for design of same 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.

C. Do not suspend pipe hangers and supports from roof deck. Suspend such loads from structural steel only, and provide structural steel sub-framing as required.

D. Do not suspend piping loads exceeding 500 pounds within any 100 square feet of contiguous area from supported concrete floor slabs. Suspend such loads from structural members only, and provide structural steel sub-framing as required.

E. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1.05 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M *Structural Welding Code – Steel*.

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."

C. ANSI/MSS Standard SP-58-2018 *Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation* including Amendment 1 Issued October 17, 2019, is hereby incorporated by reference. This Standard establishes:
   1. Minimum requirements for materials, allowable stresses, product design, testing, and load ratings for pipe hanger and support assemblies for standard and unique pipe hangers and supports.
   2. Inspection criteria for the manufacture and installation of pipe hangers and supports.
   3. Required procedures for packing, marking, shipping, receiving, and storage of pipe hangers and supports.
   4. Minimum requirements for pipe hanger and support assembly drawings.
   5. Field practices for installation, adjustment, testing, and inspection of pipe hangers and supports.
   6. Terminology and identification of pipe hangers and supports, along with recommended contractual relationship structures.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Manufactured Pipe Hangers:
      a. Anvil International, Inc.
      b. Cooper B-Line, Inc.
      c. Carpenter & Patterson, Inc.
      d. Erico International Corp.
      e. PHD Manufacturing, Inc.
      f. Tolco division of Cooper B-Line, Inc.
   2. Metal Framing Systems:
      a. Anvil International, Inc.
      b. Cooper B-Line, Inc.
      c. Erico / Michigan Hanger Co.
      d. Thomas & Betts Corporation.
      e. Tolco division of Cooper B-Line, Inc.
      f. Unistrut Corporation; Tyco International, Ltd.
   3. Thermal-Hanger Shield Inserts:
      a. Carpenter & Paterson, Inc.
      b. Erico International Corp.
      c. PHS Industries, Inc.
      d. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
   4. Powder-Actuated Fastener Systems:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Simpson Manufacturing Co.; Strong-Tie Anchor Systems Div.
   5. Roof-Mounted Pipe Stands:
      a. "Caddy Pyramid" by Erico International Corp.
      b. Mapa Products.
      c. Miro Industries, Inc.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23

Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 METAL PIPE HANGERS AND SUPPORTS

A. Application: Refer to “Hanger and Support Applications” Article in Part 3 for where to use specific hanger and support types, including special padding or coatings where required.

B. Copper Pipe Hangers: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components. Include continuous-thread hanger rods, nuts, and washer made of stainless steel.

2.03 METAL FRAMING SYSTEMS

A. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes, according to Standard MFMA-4. Galvanized steel construction.

B. Channels: Continuous slotted steel channel with inturned lips.

C. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

D. Hanger Rods: As specified for Metal Pipe Hangers and Supports above.

E. Coatings: Manufacturer’s standard finish, unless otherwise noted.

2.04 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material: ASTM C552, Type II cellular glass with 100-psig (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.

B. For Clamped Systems: Insert and shield shall cover entire circumference of pipe.

C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

D. Insert Length: Extend 2-inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.05 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.06 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:
   1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   2. Base: Stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.

4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:
1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.07 EQUIPMENT SUPPORTS

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

B. Roof Curb-Type Equipment Rails: 18-gauge galvanized steel, unitized construction with integral base plate, continuous welded corner seams, pressure-treated wood nailer, counter-flashing with screws. Internally reinforced to conform with load bearing factors. Wood nailer shall include 1-inch overhang unless otherwise noted. Subject to compliance with requirements, example of acceptable product is The Pate Company's Model ES-5b.

C. Outdoor Equipment Stands: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground-supported or roof-supported outdoor equipment components, without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.
1. Foot Material: Rubber or polypropylene.
2. Rails Material and all Hardware: Stainless steel.
3. Wind/Sliding Load Resistance: Up to 100 mph (44 m/s) minimum.

D. Design all suspended equipment supports to resist forces of 0.5 times the equipment weight in any horizontal direction and 1.5 times the equipment weight in the downward direction. These requirements shall be increased to account for forces required by other criteria, such as seismic standards, as may be specified elsewhere.

2.08 MISCELLANEOUS MATERIALS

A. Structural and Miscellaneous Steel: As specified in Division 23 Section "Basic Mechanical Materials and Methods."

B. Grout: As specified in Division 23 Section "Basic Mechanical Materials and Methods."

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT SCHEDULE OF APPLICATIONS

A. Comply with MSS SP-58 for pipe hanger selections and applications that are not specified in this Section.

B. Comply with MFMA-102 for metal framing system 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-plated pipe hangers and copper or stainless-steel attachments, or use plastic coatings on attachments for electrolytic protection, where hangers are in direct contact with copper tubing.

E. Use stainless-steel pipe hangers and supports, stainless-steel metal framing systems, and all stainless-steel hardware and attachments for all piping installed outdoors.

F. Horizontal-Piping Hangers and Supports for the first three hangers/supports or the first 50-feet (whichever is greater) adjacent to Pumps: Use spring hangers and supports. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports shall include the following types:
   1. Horizontal (MSS Type 54): Mounted horizontally.
   2. Vertical (MSS Type 55): Mounted vertically.
   3. Exception: Spring hangers are not required adjacent to inline pumps that are smaller than 5-horsepower. Use other types of hangers and supports as listed for service below.

G. Horizontal-Piping Hangers and Supports for individual pipe runs less than 20 feet long and all piping 2-inch diameter or smaller, regardless of length: Unless otherwise indicated, choose among the following types:
   1. Adjustable Steel Clevis Hangers (MSS Type 1).
   2. Yoke-Type Pipe Clamps (MSS Type 2): For pipes NPS 4 and larger.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3).
   4. Steel Pipe Clamps (MSS Type 4).

H. Horizontal-Piping Hangers and Supports for individual uninsulated pipe runs of any size or length: Unless otherwise indicated, choose among the following types:
   1. Adjustable Steel Clevis Hangers (MSS Type 1).
   2. Yoke-Type Pipe Clamps (MSS Type 2): For pipes NPS 4 and larger.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3).
   4. Steel Pipe Clamps (MSS Type 4).
   5. Adjustable Steel Band Hangers (MSS Type 7): For pipes up to NPS 2 only.
   6. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For pipes up to NPS 2 only.
   7. U-Bolts (MSS Type 24).
   8. Horizontal (MSS Type 54): Mounted horizontally.
   9. Vertical (MSS Type 55): Mounted vertically.

I. Hanger-Rod Attachments: Unless otherwise indicated, choose among the following types:
   1. Steel Turnbuckles (MSS Type 13).
   2. Steel Clevises (MSS Type 14).
   3. Malleable-Iron Sockets (MSS Type 16).
   4. Steel Weldless Eye Nuts (MSS Type 17).

J. Building Attachments: Unless otherwise indicated, choose among the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to concrete ceiling.
   2. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   3. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams.
   4. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   5. Light Welded-Steel Brackets (MSS Type 31): For support of pipes from below or for suspending from above up to 750 lb. by using clip and rod.
   6. Medium Welded-Steel Brackets (MSS Type 32): For support of pipes from below or for suspending from above up to 1500 lb. by using clip and rod.
   7. Heavy Welded-Steel Brackets (MSS Type 33): For support of pipes from below or for suspending from above up to 3000 lb. by using clip and rod.
   8. Side-Beam Brackets (MSS Type 34): For sides of steel beams.
   9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

3.02 HANGER AND SUPPORT MAXIMUM SPACING AND MINIMUM ROD SIZE

A. Install hangers and supports with the following maximum spacing and minimum rod sizes.

B. Drawn-Temper Copper Piping for any liquid-service piping systems:
   1. NPS ¾ (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 3/8-inch (10 mm).
   2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 3/8-inch (10 mm).
   3. NPS 1¼ (DN 32): Maximum span, 6 feet (1.8 m); minimum rod size, 3/8-inch (10 mm).
   4. NPS 1½ (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8-inch (10 mm).
   5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8-inch (10 mm).

C. Copper Piping for Refrigerant Suction and Refrigerant Hot Gas:
   1. NPS ¾ (DN 20): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8-inch (10 mm).
   2. NPS 1 (DN 25): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8-inch (10 mm).
   3. NPS 1¼ (DN 32): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8-inch (10 mm).
   4. NPS 1½ (DN 40): Maximum span, 10 feet (3 m); minimum rod size, 3/8-inch (10 mm).
   5. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8-inch (10 mm).
   6. NPS 2½ (DN 65): Maximum span, 10 feet (3 m); minimum rod size, 1/2-inch (13 mm).
   7. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 1/2-inch (13 mm).
   8. NPS 4 (DN 100): Maximum span, 10 feet (3 m); minimum rod size, 5/8-inch (16 mm).

D. Copper Piping for Refrigerant Liquid: Same as specified above for Drawn-Temper Copper Piping for any liquid-service piping systems.

E. Rod diameters may be reduced one size for double-rod hangers, with 3/8-inch (10 mm) minimum rods.

F. Hanger and support spacing for piping and tubing not listed above shall be according to MSS SP-58 and piping manufacturer's written instructions.

3.03 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

C. Thermal-Hanger Shield Installation: Required for insulated piping NPS 4 and larger if piping operates below surrounding ambient air temperature.

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

E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement.

F. Install lateral bracing with pipe hangers and supports to prevent swaying.

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

H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads 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.

J. Repair any building insulation or building fireproofing materials, whether new or existing, that are removed or scraped away in order to attach hangers and supports, so as to maintain an equivalent insulation or fire rating as existed without said hanger or support attachment.

K. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4-inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

L. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.

M. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

3.04 PROTECTION OF INSULATED PIPING:

A. Attach clamps and spacers to piping.
   1. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   2. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

B. Do not exceed pipe stress limits according to ASME B31.9.

C. Piping Operating above Ambient Air Temperature: Clevis- and clamp-type supports shall project through insulation, with pipe support making direct contact with pipe and with insulation applied in a manner that encapsulates the clevis or clamp. For piping on roller-type supports, install MSS SP-58, Type 39 protection saddles, and fill interior voids with insulation that matches adjoining insulation.
   1. Contractor's Option: In lieu of the above paragraph, contractor has the option of complying with the same specifications as for "Piping Operating below Ambient Air Temperature" in the following paragraphs.

D. Piping Operating below Ambient Air Temperature: Clevis- and clamp-type supports shall be sized for the outside diameter of the insulation including jacket. Install MSS SP-58, Type 40 protective metal shields. Shields shall span an arc of 180 degrees.
   1. Metal Shield Dimensions for Pipe: Not less than the following:
      a. NPS 3½ (DN 90) and smaller: 12-inches (300 mm) long and 0.048-inch (1.22 mm) thick.
   2. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.05 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead. Provide lateral bracing, to prevent swaying, for equipment supports.

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

3.06 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

B. 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. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. Obtain fusion without undercut or overlap. Remove welding flux immediately. Finish welds at exposed

connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.07 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe. Trim excess length of continuous-thread hanger and support rods to 1½-inches (40 mm).

3.08 PAINTING

A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

END OF SECTION

SECTION 23 05 40
MECHANICAL VIBRATION ISOLATION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes vibration isolation pads, mounts, hangers, and vibration isolation bases for mechanical, HVAC, plumbing, and fire protection services.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 13 Section “Seismic Restraints” for seismic restraints, snubbers, cables, and coordination with vibration controls.
   2. Division 23 Section “Basic Mechanical Materials and Methods” for flexible pipe connectors.
   3. Division 23 Section “Hangers and Supports” for pipe hanger restraints.
   4. Division 23 Section “Metal Ducts” for flexible duct connectors.
   5. Other Division 21 through 28 Sections for equipment that is to be mounted on vibration isolation.

1.03 SUBMITTALS

A. Product Data: types, styles, materials, and finishes for each type of isolator specified. Include load deflection curves for each vibration isolation device.

B. Welding certificates.

C. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in Division 13 Section “Seismic Restraints.”

D. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

A. Single-Source: All vibration isolation devices shall be the product of a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1, “Structural Welding Code – Steel.”

1.05 COORDINATION

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

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Sections.

PART 2 - PRODUCTS

2.01 GENERAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers listed in Division 13 Section “Seismic Restraints.” Single-source responsibility is required; the contractor shall furnish products under Division 13 Section “Seismic Restraints” and under this Section by the same manufacturer.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

C. Model numbers by Mason Industries, Inc. are listed below to establish the level of quality required; equal products by other listed manufacturers are acceptable under the “Material and Equipment Selection” terms of Division 23 Section “Basic Mechanical Requirements.”

D. All neoprene referred to hereinafter shall be oil resistant, compounded for not greater than 65 durometer, minimum tensile strength of 2000 psi, minimum elongation of 300%, and maximum compression set at 25% of the original deflection.

E. Where exposed to the atmosphere, all steel shall be hot dipped galvanized unless noted otherwise.

F. All hardware shall be cadmium plated, and all springs shall be neoprene coated.

2.02 VIBRATION ISOLATORS

A. Elastomeric Isolator Pads (Schedule Designation Type 1): Oil and water resistant and factory cut to sizes that match requirements of the equipment supported. Load range from 10 to 50 psig (69 to 345 kPa) and a deflection not less than 0.08-inch per 1-inch (2 mm per 25 mm) of thickness. Do not exceed a loading of 50 psig (345 kPa). Neoprene arranged in single or multiple layers, molded with a non-slip ribbed or waffled pattern, and steel baseplates of sufficient stiffness to provide uniform loading over the pad area. Provide 5/16-inch minimum thickness. Provide 1/16-inch galvanized steel plate between multiple layers. Model MBSW by Mason Industries, Inc.

B. Elastomeric Mounts (Schedule Designation Type 2): Double-deflection type, with molded, neoprene isolator elements, with encapsulated top- and baseplates. Factory-drilled and tapped top plate for bolted equipment mounting. Factory-drilled baseplate for bolted connection to structure. Color-code to indicate capacity range. Model ND by Mason Industries, Inc.

C. Restrained Elastomeric Mounts (Schedule Designation Type 2R): All-directional elastomeric mountings with seismic restraint. Model RBA/RCA by Mason Industries, Inc.
   1. Materials: Cast-ductile-iron housing containing two separate and opposing, molded, bridge-bearing neoprene elements that prevent central threaded sleeve and attachment bolt from contacting the casting during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Spring Isolators (Schedule Designation Type 3): Freestanding, laterally stable, open-spring-type isolators. Design and install such that ends of springs remain parallel. Model SLF by Mason Industries, Inc.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 1.2 times the rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to ½-inch- (13-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig (690 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolators (Schedule Designation Type 4): Same as Spring Isolators specified above, plus the following: Welded steel housing with resilient vertical limit stops to prevent spring extension due to wind loads or when weight is removed. Provide adjustable equipment mounting and leveling bolt. Unit shall be capable of supporting equipment at a fixed elevation during equipment erection. Model SLR by Mason Industries, Inc.

F. Elastomeric Hangers (Schedule Designation Type 2H): Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range. Model HD by Mason Industries, Inc.

G. Spring Hangers (Schedule Designation Type 3H): Combination coil-spring and elastomeric-insert hanger with spring and insert in compression. Model 30N by Mason Industries, Inc.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

H. Spring Hangers with Vertical-Limit Stop (Schedule Designation Type 3HR): Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop. Model PC30N by Mason Industries, Inc.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer “up-stop” on lower threaded rod.

I. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of ½-inch thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

J. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of ½-inch thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.03 VIBRATION ISOLATION EQUIPMENT BASES

A. Steel Base (Schedule Designation Type B): Factory-fabricated, welded, structural-steel bases and rails. Model WFSL by Mason Industries, Inc.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps. Include equipment static loadings, power transmission, component misalignment, and cantilever loadings.
   2. Structural Steel: Fabricate bases to shapes required, with welded structural-steel shapes, plates, and bars conforming to ASTM A 36 (ASTM A 36M). Include support brackets to anchor base to isolation units. Include pre-located equipment anchor bolts and auxiliary motor slide bases or rails. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

2.04 RESTRAINED VIBRATION ISOLATION SEISMIC ROOF-CURB RAILS

A. Description (Schedule Designation Type D): Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand 125-mph (56-m/s) wind impinging laterally against side of equipment. Model SRSC by Mason Industries, Inc.

B. Lower Support Assembly: Sheet-metal “Z” section containing adjustable and removable steel springs that support upper floating frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind and seismic forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2-inches (50 mm) of rigid, glass-fiber insulation on inside of assembly.

C. Overall Height: Minimum 18-inches (450 mm).

D. Elastomeric Isolator Pads: Schedule Designation Type 1 as specified above.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least ¼-inch (6 mm) thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

G. Accessories: Provide the following accessories where scheduled, noted, or otherwise indicated on Drawings:
   1. Integrated Pitch Corrections: Where shimming cannot compensate for unusual roof deck pitch, provide Integrated Pitch Corrections. Provide a level isolation curb with lower members that follow the pitch in the roof.

2.05 FACTORY FINISHES

A. Manufacturer’s standard prime-coat finish ready for finish painting.

B. Finish: Manufacturer’s standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be electrogalvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements, installation tolerances, and other conditions affecting performance. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Install vibration control products in accordance with manufacturer's written instructions. Positive attachment of vibration control products to the isolated equipment is required. Positive attachment of vibration control products to the structure or floor is required. Do not rely on friction or gravity as a means of attachment.

C. Install roof curbs, equipment supports, and roof penetrations as specified in Division 07 Section "Roof Accessories."

D. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure. Seismic snubbers are specified in Division 13 Seismic Restraints," whose requirements apply to the work of this Section as if fully reproduced herein.

E. Install resilient bolt isolation washers on equipment anchor bolts.

3.02 ADJUSTING

A. 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.

B. Adjust active height of spring isolators.

C. Adjust snubbers according to manufacturer's written recommendations.

D. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

E. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.03 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.04 VIBRATION ISOLATOR SCHEDULE

A. Select and provide specific types of Vibration Isolators as scheduled below; if not scheduled, then as listed in Table 47, Chapter 49 of the *2019 ASHRAE Handbook of HVAC Applications*.

B. All of the Vibration Isolators Scheduled are field-supplied and field-installed external to the respective equipment unit. See each individual Division 23 specification section for additional factory-installed Vibration Isolators internal to each respective equipment unit.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
   1. Balancing airflow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
   2. Adjusting total HVAC systems to provide indicated quantities.
   3. Measuring electrical performance of HVAC equipment.
   4. Reporting results of the activities and procedures specified in this Section.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
   2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.

1.03 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. AMCA: Air Movement and Control Association.

C. NEBB: National Environmental Balancing Bureau.

D. SMACNA: Sheet Metal and Air Conditioning Contractors’ National Association.

1.04 SUBMITTALS

A. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

1.05 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by either AABC or NEBB.

B. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports.

C. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC *National Standards for Total System Balance, 7th Edition* or from NEBB’s “Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.”

D. Instrumentation Type, Quantity, and Accuracy: As described in AABC *National Standards for Total System Balance, 7th Edition* or in NEBB’s “Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems,” Section II, “Required Instrumentation for NEBB Certification” except where more stringent requirements are specified in this Section.

E. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.06 PROJECT CONDITIONS

A. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire testing, adjusting, and balancing period. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

1.07 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after leakage and pressure tests on air distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine equipment performance data, including fan curves.

D. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

E. Examine air-handling equipment to ensure clean filters have been installed.

F. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible.

G. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.02 PREPARATION

A. Before beginning testing, adjusting and balancing, verify the following:
   1. Permanent electrical power wiring is complete.
   2. Automatic temperature-control systems are operational.
   3. Equipment and duct access doors are securely closed.
   4. Balance, smoke, and fire dampers are open.
   5. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   6. Windows and doors can be closed so design conditions for system operations can be met.

3.03 TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC *National Standards for Total System Balance, 7th Edition* or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" except where more stringent requirements are specified in 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 the insulation Specifications for this Project.

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

D. Set HVAC system airflow flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans: Plus or minus 5 percent.
   2. Air Outlets and Inlets: Plus or minus 5 percent.

3.04 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-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. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the certified field report data, include fan curves.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of testing, adjusting, and balancing Agent.
   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 testing, adjusting, and balancing Agent who certifies the report.
   10. Summary of contents, including design versus final performance, notable characteristics of systems, and description of system operation sequence if it varies from the Contract Documents.
   11. Nomenclature sheets for each item of equipment.
   12. Data for terminal units, including manufacturer, type size, and fittings.
   13. Notes to explain why certain final data in the body of reports vary from design values.
   14. Test conditions for fans performance forms.

E. System Diagrams: Include schematic layouts of air distribution systems with a keyed identification system for each device.

F. Air-Handling Unit Test Reports.

G. Apparatus-Coil Test Reports: For all air handling unit coils.

H. Fan Reports: For all supply, return, and exhaust fans.

I. Duct Traverse Reports.

J. Air-Terminal-Device Reports: For each terminal unit, air inlet, and air outlet.

K. Instrument Calibration Reports: For instrument calibration, include instrument type and make, serial number, application, dates of use, and dates of calibration.

END OF SECTION

SECTION 23 07 00
MECHANICAL INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes mechanical insulation for ductwork and piping and other installations, including the following:
   1. Insulation Materials: Flexible elastomeric and mineral fiber.
   2. Insulating cements, adhesives, mastics, and sealants.
   3. Factory-applied jackets.
   4. Field-applied fabric-reinforcing mesh.
   5. Field-applied jackets.
   6. Tapes and securements.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 23 Section “Metal Ducts” for internal duct liners and pre-insulated ductwork.

1.03 DEFINITIONS

A. ASJ: All-service jacket.

B. FSK: Foil, scrim, kraft paper.

C. SSL: Self-sealing lap.

D. Thermal Resistivity: “R-values” represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogenous material exactly 1-inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between two exposed faces required to cause one BTU to flow through one square foot of material, in one hour, at a given mean temperature.

E. VOC: Volatile Organic Compound as defined by LEED v4 Credit EQc2.

F. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, and spaces above ceilings.

G. Exposed Installations: Exposed to view. Examples include finished occupied spaces without ceilings, mechanical equipment rooms, courtyards and rooftop locations.

H. Concealed Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings or within duct shafts.

I. Conditioned Space: Spaces that are served by both a mechanical heating and mechanical cooling system are conditioned spaces. Heating-only spaces are not conditioned spaces. The space above a ceiling is considered conditioned space if the space directly below that ceiling is conditioned space. A vertical shaft is considered conditioned space if the spaces on all sides surrounding the shaft are conditioned spaces.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated, identify thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. MSDS (Material Safety Data Sheet) for each adhesive, mastic, sealant, and cement furnished.

C. LEED Submittals: Submit product data for LEED v4 Credit EQc2 for each adhesive, mastic, sealant, and cement, including printed statement of VOC content.

D. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Exception: Flame-spread index of 25 or less, and smoke-developed index of 150 or less; is acceptable for insulation not installed in an air-handling duct, plenum, space above ceilings if used as a return air plenum, or air-handling equipment rooms if used as a return/exhaust/relief air plenum, or any other air-handling situation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.07 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section “Hangers and Supports.”

B. Coordinate clearance requirements with piping Installer for piping insulation application and duct Installer for duct insulation application. Establish and maintain clearance requirements for installation of insulation and finishes and for space required for maintenance.

1.08 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Flexible Elastomeric Insulation:
    1. Aeroflex USA Inc.; Aerocel.
    2. Armacell LLC; AP/Armaflex.
    3. K-Flex USA; Insul-Lock® Seam-Seal.
    4. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
2. Mineral Fiber Insulation:
    1. CertainTeed Corp.
    2. Johns Manville.
    3. Knauf Insulation.
    4. Manson Insulation Inc.
    5. Owens Corning.

3. Insulating Cements: Same as insulation manufacturer, or
    1. Insulco, Division of MFS, Inc.
    2. P. K. Insulation Mfg. Co., Inc.
    3. Rock Wool Manufacturing Company.
4. Sealants, Adhesives and Mastics: Same as insulation manufacturer, or
    1. H.B. Fuller Construction Products Inc. (Childers and/or Foster brands)
    2. ITW TACC, Division of Illinois Tool Works.
    3. Marathon Industries, Inc.
    4. Mon-Eco Industries, Inc.
    5. Vimasco Corporation.
5. Field-Applied Jackets: Same as insulation manufacturer, or
    1. P.I.C. Plastics, Inc.
    2. PABCO Metals Corporation.
    3. Pittsburgh Corning Corporation.
    4. Polyguard Products, Inc.
    5. Proto PVC Corporation.
    6. RPR Products, Inc.
    7. Speedline Corporation.
6. Tapes: Same as insulation manufacturer, or
    1. Avery Dennison Corporation, Specialty Tapes Division.
    2. Compac Corp.
    3. Ideal Tape Co., Inc., an American Biltrite Company.
    4. Polyguard Products, Inc.
    5. Venture Tape.
7. Bands and Wire: Same as insulation manufacturer, or
    1. ACS Industries, Inc.
    2. C & F Wire.
    3. Childers Products.
    4. PABCO Metals Corporation.
    5. RPR Products, Inc.
8. Insulation Pins and Hangers: Same as insulation manufacturer, or
    1. AGM Industries, Inc.
    2. GEMCO.
    3. Midwest Fasteners, Inc.
    4. Nelson Stud Welding.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 INSULATION MATERIALS

A. Refer to Schedule in Part 4 for requirements about where insulating materials shall be applied.

B. Restrictions: Products shall not contain asbestos, lead, mercury, or mercury compounds. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

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

D. Product manufacturers and/or their product numbers notwithstanding, each adhesive, mastic, sealant, and cement shall have a VOC content not greater than the maximum allowable under LEED v4 Credit EQc2 regardless of whether or not this project is seeking LEED certification.

E. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.
   1. Thermal Conductivity: 0.28 average maximum at 75ºF mean temperature using test method ASTM C177 or C518.
   2. Water Vapor Permeability: Maximum 0.1 perm-inch using test method ASTM E96 Procedure A.
   3. Water Absorption: Maximum 0.2% by volume using test method ASTM C209.
   4. Product shall pass mold growth, fungi resistance, and bacterial resistance tests per UL 181, ASTM G21, G22, and C1338.
   5. Adhesive: Comply with MIL-A-24179A, Type II, Class I; VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied jacket.
   1. Thermal Conductivity: 0.26 average maximum at 75°F mean temperature.
   2. Density: 1.5 lb/cf (24-kg/cu. m) minimum.
   3. Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB.
   1. Thermal Conductivity: 0.26 average maximum at 75°F mean temperature.
   2. Density: 2.0 lb/cf (32-kg/cu. m) minimum.
   3. Jacket (Ducts): Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.03 CEMENTS AND MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates. Comply with ASTM C755-19 *Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation* Table 2, for the selection of vapor retarder systems.

B. Insulating Cements: Select one or more of the following at contractor's option.
   1. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
   2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
   3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below-ambient services, for applications on seams, punctures, penetrations, and terminations of vapor retarder membranes. Equal to Foster 30-80 or Childers CP-35 or Vimasco 749.
   1. Service Temperature Range: -20 to +180ºF (-29 to +82ºC).
   2. Solids Content: ASTM D1644, 59 percent by volume and 71 percent by weight.
   3. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services. Equal to Foster 46-50 or Childers CP-10/11 or Vimasco WC-5.
   1. Water-Vapor Permeance: ASTM F1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   2. Service Temperature Range: -20 to +200ºF (-29 to +93ºC).
   3. Solids Content: 63 percent by volume and 73 percent by weight.
   4. Color: White.

2.04 SEALANTS

A. Joint Sealants: Permanently flexible, elastomeric sealant. Materials shall be compatible with insulation materials, jackets, and substrates.
   1. Service Temperature Range: -100 to +200ºF (-73 to +94ºC).

2. Color: White, tan, or gray.
3. VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants: Fire- and water-resistant, flexible, elastomeric sealant. Materials shall be compatible with insulation materials, jackets, and substrates.
1. Service Temperature Range: -40 to +250ºF (-40 to +121°C).
2. Color: Aluminum.
3. VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants: Fire- and water-resistant, flexible, elastomeric sealant. Materials shall be compatible with insulation materials, jackets, and substrates.
1. Service Temperature Range: -40 to +250ºF (-40 to +121°C).
2. Color: White.
3. VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.05 FIELD-APPLIED CLOTHS AND FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Duct Insulation: Approximately 4 oz./sq. yd. (135 g/sq. m) with a thread count of 5 strands by 5 strands/sq.-inch (2 strands by 2 strands/sq. mm); equal to Childers Chil Glas #5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq.-inch (4 strands by 4 strands/sq. mm), in a Leno weave for duct equal to Foster Mast-a-Fab.

2.06 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness 30 mils (0.8 mm); roll stock ready for shop or field cutting and forming.
1. Adhesive: Compatible with PVC, as recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
4. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
5. Factory-fabricated tank heads and tank side panels

C. Metal Jackets: Sheet and roll stock ready for shop or field sizing. Factory pre-cut and rolled to size is also acceptable.
1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14. Finishes and thickness as follows:

2. Indoor Ducts and Plenums: Smooth, 0.016-inch (0.41 mm) thick.
3. Indoor Equipment: Stucco Embossed, 0.016-inch (0.41 mm) thick.
4. Outdoor Ducts, Equipment, and Piping: Stucco embossed, with Z-shaped locking seam, 0.024-inch (0.61 mm) thick.

D. Stainless-Steel Jacket: ASTM A167 or ASTM A240; Type 304 stucco embossed, with Z-shaped locking seam; 0.016-inch (0.41 mm) thick.

E. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

F. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

G. Factory-Fabricated Fitting Covers: Same material, finish, and thickness as jacket; provide as required for preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows, tee covers, flange and union covers, end caps, beveled collars, and valve covers.
H. Field-fabricate fitting covers only if factory-fabricated fitting covers are not available

2.07 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136 and UL listed.
   1. Width: 3-inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136 and UL listed.
   1. Width: 3-inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   1. Width: 2-inches (50 mm).
   2. Thickness: 6 mils (0.15 mm).
   3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL listed.
   1. Width: 2-inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.08 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A167 or ASTM A240, Type 304; 0.015-inch (0.38 mm) thick, ½-inch (13 mm) wide with wing or closed seal.
   2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch (0.51 mm) thick, ½-inch (13 mm) wide with wing or closed seal.
   3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1½-inch (38-mm) galvanized carbon-steel washer.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick, aluminum or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1½-inches (38 mm) in diameter. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal ¾-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application. Verify that systems to be insulated have been tested and are free of defects. Verify that surfaces to be insulated are clean and dry. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

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

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

3.03 COMMON INSTALLATION REQUIREMENTS

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

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

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

D. Install insulation with longitudinal seams at top and bottom of horizontal runs. Install multiple layers of insulation with longitudinal and end seams staggered.

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

F. Keep insulation materials dry during application and finishing.

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

H. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

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

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

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

L. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4-inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

M. At the following locations, omit jacket and provide a separate cutaway removable segment of insulation clearly labeled “Access.” For below-ambient services, provide a design that allows access but maintains vapor barrier.
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   4. Manholes.
   5. Handholes.
   6. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations:
   1. Install pipe insulation continuously through pipe penetrations of fire-rated walls and partitions.
   2. Install duct insulation continuously through duct penetrations of fire-rated walls and partitions, for cases where no fire damper is required.
   3. Terminate duct insulation at fire damper sleeves for cases where fire dampers are used but overlap duct insulation at least 2-inches (50 mm) onto sleeve.
   4. Firestopping and fire-resistive joint sealers are specified in Division 07 Section “Penetration Firestopping.”

E. Insulation Installation at Floor Penetrations:
   1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2-inches (50 mm).
   2. Pipe: For below-ambient piping services, install insulation continuously through floor penetrations. For above-ambient piping services, either do the same as for below-ambient

piping, or it is acceptable to install uninsulated piping through the slab and butt the pipe insulation tight to the slab on both the top side and the underneath side.

3. Seal penetrations through fire-rated assemblies according to Division 07 Section "Penetration Firestopping."

3.05 DUCT INSULATION INSTALLATION

A. See Part 4 Insulation Schedules for specific requirements.

B. The following ductwork items need not be insulated, unless noted otherwise:
   1. Metal ducts with internal duct liner.
   2. Pre-insulated duct systems.
   3. Factory-insulated flexible ducts.
   4. Factory-insulated plenums, casings, fan housings, and air terminal units.
   5. Flexible connectors.
   6. Vibration-control devices.
   7. Factory-insulated access panels and doors.

C. Secure all insulation on ducts with insulation pins. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   1. On duct sides with dimensions 18-inches (450 mm) and smaller, pins may be omitted.
   2. On duct sides with dimensions 18-inches (450 mm) and larger, place pins along longitudinal centerline of duct. Space 3-inches (75 mm) maximum from insulation end joints, and 16-inches (400 mm) o.c.
   3. On duct sides with dimensions larger than 36-inches (900 mm), place pins 16-inches (400 mm) o.c. each way, and 3-inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   4. Pins may be omitted from top surface of horizontal, rectangular ducts.
   5. Do not over-compress insulation during installation.
   6. If using blanket insulation, impale insulation over pins and attach speed washers.
   7. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

D. For ducts with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2-inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with ½-inch (13-mm) outward-clinching staples, 1-inch (25 mm) o.c. Complete the vapor barrier by applying FSK tape specified in Part 2, or vapor-barrier mastic and sealant, at all joints, seams, and protrusions.
   1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

E. If using blanket insulation, overlap unfaced blankets a minimum of 2-inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18-inches (450 mm) o.c.

F. Unless factory-insulated, install duct insulation continuously and unbroken over duct-mounted accessories such as fans, coils, terminal units, damper housings, airflow measuring station housings, etc.

G. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. If using board insulation, groove and score insulation to fit as closely as possible to outside and inside radius of elbows.

H. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

I. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-(150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6-inches (150 mm) o.c.

3.06 PIPE INSULATION INSTALLATION

A. See Part 4 Insulation Schedules for specific requirements.

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

C. Flexible Elastomeric Insulation Installation: Seal all transverse seams, longitudinal seams, end joints, and section joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.07 FIELD-APPLIED JACKET INSTALLATION

A. See Part 4 Insulation Schedules for specific requirements.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12-inches (300 mm) o.c. and at end joints

3.08 FINISHES

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

PART 4 - SCHEDULES

4.01 INSULATION SCHEDULES

A. Furnish and install duct and piping insulation as specified above and in accordance with the schedules below. All insulation thicknesses and pipe sizes in the following tables are given in nominal inches. Where more than one type of allowable material or more than one type of field jacket is listed, the choice is contractor’s option.

B. Cold Surfaces: For piping and ductwork surfaces operating below surrounding ambient temperature (including supply, return, and exhaust air ductwork associated with the rooftop unit(s) routed through areas that are not air-conditioned), all surfaces including but not limited to pipe, duct, flanges, fittings, valves of every kind, dampers, strainers, unions, and other appurtenances shall be insulated and shall include uninterrupted vapor barrier to avoid potential condensation.

DUCT INSULATION	Duct	Duct	Minimum	Allowable	Insulation	Field	Keyed
Service	Shape	Location	R-Value	Materials	Thickness	Jacket	Notes
Supply Air Service	Round, Oval	ICC,ICN	R-3.5	FGBK	1.50	---	(4)
		IEC,IEN	R-3.5	FGBK	1.50	AL	(3) (4)
	Rectangular	ICC,ICN	R-3.5	FGBK	1.50	---	(4)
		IEC,IEN	R-3.5	FGBD	1.50	---	(4)

Return Air Service	Round, Oval	ICC,IEC	---	---	---	---	
		ICN	R-3.5	FGBK	1.50	---	(4)
		IEN	R-3.5	FGBK	1.50	AL	(3) (4)
	Rectangular	ICC,IEC	---	---	---	---	
		ICN	R-3.5	FGBK	1.50	---	(4)
		IEN	R-3.5	FGBD	1.50	---	(4)
Exhaust Air Service	Round, Oval	ICC, IEC	R-3.5	FGBK	1.50	---	(2) (4)
		ICN, IEN	R-3.5	FGBK	1.50	---	(1) (4)
	Rectangular	ICC, IEC	R-3.5	FGBK	1.50	---	(2) (4)
		ICN, IEN	R-3.5	FGBD	1.50	---	(1) (4)

KEYED NOTES:

(1) *Insulate only if the exhaust is routed to an energy-recovery device.*
(2) *Insulate only between final isolation damper and penetration of building exterior.*
(3) *The specified field jacket is required only if less than 84-inches AFF.*
(4) *Omit insulation if duct is expressly called out to be internally lined.*

LEGEND:

ICC	Indoor, Concealed, in Conditioned space	AL	Aluminum
ICN	Indoor, Concealed, in Non-conditioned space	SS	Stainless Steel
IEC	Indoor, Exposed, in Conditioned space		
IEN	Indoor, Exposed, in Non-conditioned space		
FGBK	Fiberglass Insulation, 1.5-lb density, Blanket		
FGBD	Fiberglass Insulation, 1.5-lb density, Board		

PIPE INSULATION Services	Temperature Range °F	Size Range	Location	Allowable Materials	Thick- ness	Field Jacket	Keyed Notes
Coil condensate	below 60	¾ to 6	Indoors	FE	0.50	---	
Refrigerant suction and hot gas piping	All	All	Indoors	FE	1.00	---	
			Outdoors	FE	2.00	AL,SS	

KEYED NOTES:

LEGEND:

FE	Flexible Elastomeric
MF	Mineral Fiber
AL	Aluminum
SS	Stainless Steel

END OF SECTION

SECTION 23 08 00
FUNDAMENTAL AND ENHANCED COMMISSIONING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Section 23 01 00 “Basic Mechanical Requirements” and Section 23 05 00 “Basic Mechanical Materials and Methods” apply to the work of this Section as if fully repeated herein.

C. Owner's Project Requirements (OPR) and Basis of Design (BoD) documentation are included by reference for information only.

1.02 SUMMARY

A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.

B. Perform all commissioning required to achieve the following:
   1. LEED-NC v4 – Prerequisite EAp1 for “Fundamental Commissioning.”
   2. LEED-NC v4 – Credit EAc1 for “Enhanced Commissioning.”

A. Perform commissioning in accordance with relevant criteria documented in United States Green Building Council’s (USGBC) Leadership in Energy Efficient Design (LEED) and ASHRAE Guideline 0-2005 and Guideline 1.1-2007.

C. Related Sections: Division 01 Section “General Commissioning Requirements” for general commissioning process requirements.

1.03 DEFINITIONS

A. BoD: Basis of Design. A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

B. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

C. Commissioning Authority: Independent of the design and/or construction teams.

D. LEED-NC: Leadership in Energy and Environmental Design for New Construction, as defined by the United States Green Building Council.

E. OPR: Owner's Project Requirements. A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

F. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean “as-built” systems, subsystems, equipment, and components.

1.04 REFERENCED STANDARDS

A. Perform HVAC functional performance testing in accordance with ASHRAE Guideline 1-1996 *The HVAC Commissioning Process* and ASHRAE Guideline 1.1-2007 – *HVAC&R Technical Requirements for The Commissioning Process*. These guidelines describe the commissioning process that will ensure heating, ventilating, and air-conditioning (HVAC) systems perform in conformity with design intent.

B. Perform Commissioning in accordance with ASHRAE Guideline 0-2005 *The Commissioning Process*. This Guideline describes the Commissioning Process capable of verifying that a facility and its systems meet the Owner’s Project Requirements. The procedures, methods, and

documentation requirements in this guideline describe each phase of the project delivery and the associated Commissioning Processes from pre-design through occupancy and operation.

1.05 COMMISSIONING TEAM

A. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the Commissioning Authority.

B. Members Appointed by Owner:
   1. Commissioning Authority: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the Commissioning Authority under a separate contract.
   2. Representatives of the facility user and operation and maintenance personnel.
   3. Architect and engineering design professionals.

1.06 OWNER'S RESPONSIBILITIES

A. Provide the OPR documentation to the Commissioning Authority and each Contractor for information and use.

B. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

C. Provide the BoD documentation, prepared by Architect and approved by Owner, to the Commissioning Authority and each Contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

1.07 CONTRACTOR'S RESPONSIBILITIES

A. Each Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
   1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
   2. Cooperate with the Commissioning Authority for resolution of issues recorded in the Issues Log.
   3. Review and accept construction checklists provided by the Commissioning Authority.
   4. Review and accept commissioning process test procedures provided by the Commissioning Authority.

B. Perform commissioning tests at the direction of the Commissioning Authority.

C. Attend construction phase controls coordination meeting.

D. Attend testing, adjusting, and balancing review and coordination meeting.

E. Participate in systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the Commissioning Authority.

F. Provide information requested by the Commissioning Authority 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.

1.08 COMMISSIONING AUTHORITY'S RESPONSIBILITIES

A. Organize and lead the commissioning team.

B. Provide commissioning plan.

C. Convene commissioning team meetings.

D. Provide Schematic Design review to verify that each commissioned feature or system meets the owner's requirements relative to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts.

E. Provide Construction Document review to ensure that commissioning is adequately specified and to verify that each commissioned system or assembly meets the owner's requirements relative to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts.

F. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the Commissioning Authority will report the failure in the Issues Log.

G. Provide Project-specific construction checklists and commissioning process test procedures for actual systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

H. Prepare and maintain the Issues Log.

I. Prepare and maintain completed construction checklist log.

J. Focused Review of Submittals: Review the contractor's standard submittals of commissioned systems and assemblies to verify that the feature being provided will meet the owner's project requirements, particularly as it relates to environmentally responsive characteristics.

K. Witness systems, assemblies, equipment, and component startup.

L. Direct commissioning testing.

M. Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

N. Verify testing, adjusting, and balancing of Work are complete.

O. Near-Warranty End or Post-Occupancy Review: Return to the site 10 months into the 12-month warranty period.
   1. Review status of building operation with facility staff.
   2. Address the condition of outstanding issues related to the owner's project requirements.
   3. Interview the facility staff to identify problems or concerns they have in operating the building as originally intended.
   4. Provide suggestions for improvements and record these changes in the Systems Manual.
   5. Identify problems that are covered under warranty or under the original construction contract.
   6. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

P. Except as otherwise noted, complete all submittals and documentation described in this Section.

1.09 COMMISSIONING DOCUMENTATION

A. Provide the following information to the Commissioning Authority 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 systems, assemblies, equipment, and components to be verified and tested.

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

1.10 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

C. Schematic Design Review Report.

D. Construction Documents Review Report.

E. Systems Manual, including and indexed to the following:
1. Final version of the Owner's project requirements and basis of design.
2. As-built sequences of operation for all equipment as provided by the design professionals and contractors, including time-of-day schedules and schedule frequency, and detailed point listings with ranges and initial setpoints.
3. Ongoing operating instructions for all energy-and water-saving features and strategies.
4. Functional performance tests results (benchmarks), blank test forms, and recommended schedule for ongoing benchmarking.
5. Seasonal operational guidelines.
6. Recommendations for recalibration frequency of sensors and actuators by type and use.
7. Single-line diagrams of each commissioned system.
8. Troubleshooting table for ongoing achievement of the owner's project requirements.
9. Guidelines for continuous maintenance of the owner's project requirements (operational requirements) and basis of design (basis of operation).

F. Copy of Contract for Near-Warranty End or Post-Occupancy services.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 TESTING PREPARATION

A. Certify that systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that 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 Commissioning Authority.

3.02 TESTING AND BALANCING VERIFICATION

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

B. Notify the Commissioning Authority at least 10 days in advance of testing and balancing Work and provide access for the Commissioning Authority to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of systems at the direction of the Commissioning Authority.
   1. The Commissioning Authority will notify the party responsible for testing and balancing 10 days in advance of the date of field verification. Notice will not include data points to be verified.
   2. The party responsible for testing and balancing 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 Commissioning Authority so verification of failed portions can be performed.

3.03 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the Commissioning Authority.

B. Scope of testing shall include entire installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. 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 Commissioning Authority along with the parties responsible for installation, testing and balancing, and Instrumentation and Control shall prepare detailed testing plans, procedures, and checklists for 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 Commissioning Authority and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The Commissioning Authority may direct that set points be altered when simulating conditions is not practical.

H. The Commissioning Authority 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 system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.04 SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Section “HVAC Instrumentation and Controls.” Assist the Commissioning Authority with preparation of testing plans.

B. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The Commissioning Authority shall determine the sequence of testing and testing procedures for each equipment item to be tested.

C. Air Economizer Testing: Perform field functional testing of the economizer and complete Form NRCA-MCH-05-A NA7.5.4 *Air Economizer Controls Acceptance*. Submit the Certificate of Acceptance.

D. 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 terminal equipment and unitary equipment.

E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION

SECTION 23 09 00
HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.01 SUMMARY OF REQUIREMENTS

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. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.

C. The building temperature control system shall be direct digital control with all electric and electronic systems, communication, and devices.

D. An Ethernet-based user interface shall permit interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

E. The temperature control system requirements are defined throughout the Contract Drawings and Specifications, including but not limited to this Section, control schedules and diagrams on the Drawings, and references in the other specification sections. The party responsible for performance of the work of this Section shall review the Documents thoroughly to determine system requirements. Any temperature control system requirement called for in one location in the Contract Drawings and Specifications shall be considered a part of this Section as if fully repeated herein.

F. The temperature control system shall be based on a universal open protocol providing true open communication, interpretability, and integration of building subsystems. Refer to "References" subsection of this Section for examples of acceptable open protocols.

G. In addition to the above, the control system shall interface with the following:
   1. Fire alarm system specified in Division 28.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 22 Section “Facility Natural-Gas Piping” for gas metering.
   2. Division 22 Section “Domestic Water Piping Specialties” for domestic water metering.
   3. Division 23 Section “Commissioning.” Work of this Section shall include personnel assistance and use of software, cables, and training provided under this Section, to support the Commissioning process.
   4. Division 23 Section “Testing, Adjusting and Balancing.” Work of this Section shall include personnel assistance and use of software, cables, and training provided under this Section, to support the testing, adjusting, and balancing process.
   5. Division 23 Section “Duct Accessories” for automatic control dampers, smoke and fire/smoke dampers mounted in HVAC systems and equipment.
   6. All Division 23 Sections for coordination of HVAC equipment and systems to be controlled by the building temperature control system.

7. Division 25 Section “Switchboards” for electrical metering.

1.03 DEFINITIONS

A. General: Refer to Division 01, and Division 23 Section “Basic Mechanical Materials and Methods” for additional definitions beyond those identified here.
   1. AFMS: Airflow measurement station.
   2. BAS: Building Automation System; i.e., the system provided herein.
   3. DDC: Direct-digital controls.
   4. DZR Brass: Dezincification-resistant brass alloy containing not more than 15% zinc by weight.
   5. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.
   6. I/O: Input/output.
   7. IP: Internet Protocol.
   8. JACE: Java Application Control Engine.
   9. LAN: Local area network.
   10. LCD: Liquid crystal display.
   11. mA: Milli-ampere.
   12. MS/TP: Master-slave/token-passing.
   13. PC: Personal computer.
   14. PID: Proportional plus integral plus derivative.
   15. RTD: Resistance temperature detector.
   16. VAC: Volts, alternating current.
   17. VDC: Volts, direct current.

1.04 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Point-and-Click Graphics: All graphics shall depict realistic representations of floor plans, equipment layouts, and locations. All monitored and controlled points shall be included in the graphics. Graphics shall allow navigation through selection of equipment, or by navigating through floor plans.
   2. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   3. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   4. Graphics Time Lapse: Full graphics page for analyzing and troubleshoot systems up to 24 hours of past operation.
   5. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
   6. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
   7. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
   8. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
   9. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

10. Energy Dashboard and Reports: Energy dashboard that identifies abnormal energy usage per meter, real-time views of energy usage, year-over-year energy cost and other energy analyst tools. The dashboard shall be able to be modified by an operator. Also, can export reports with trends and graphics.

B. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
1. Space Temperature: Plus or minus 1ºF (0.5ºC).
2. Ducted Air Temperature: Plus or minus 1ºF (0.5ºC).
3. Outside Air Temperature: Plus or minus 2ºF (1.0ºC).
4. Dew Point Temperature: Plus or minus 3ºF (1.5ºC).
5. Temperature Differential: Plus or minus 0.25ºF (0.15ºC).
6. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
7. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
8. Airflow (Terminal): Plus or minus 10 percent of full scale.
9. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
10. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
11. Carbon Dioxide: Plus or minus 50 ppm (or plus or minus 5% of reading at 1,000 ppm).
12. Electrical: Plus or minus 5 percent of reading.

C. The successful Contractor shall provide a BAS system board or other hardware (if required) and the required software to Engineer so that internet connection may be made between the project and Engineer's [and Commissioning Agent's] office during the Warranty [and commissioning] period. The intent is to allow the Engineer lowest level Operator access during system installation, startup and demonstration. This shall be made available to the Engineer as soon as internet connection is available. The party responsible for performance of this Section is responsible for requesting connection and coordinating its installation.

1.05 CONNECTIVITY

A. The management and automation IP appliances such as servers, workstations, building controllers and switches shall connect via a dedicated IP network or an owner provide VLAN.

B. The field controllers shall connect via dedicated IP network, owner provide VLAN or 485- MSPT bus.

1.06 SEQUENCES OF OPERATION

A. An Input/Output Point Summary Matrix, Control Diagrams, and a written Sequence of Operation for each system appears on the Contract Drawings.

B. Provide anti-short cycle delays, minimum on/off times, dead-bands, and software interlocks for each control point as customary or appropriate, whether or not mentioned specifically in the Sequences of Operation.

C. For every item of equipment controlled, provide customary and appropriate staging, sequencing and scheduling controls; including night setup/setback, Optimal Start Heating, Optimal Start Cooling, Occupied/Unoccupied states, alarming, and trend-logging.

D. Airside Control Sequences: Control diagrams, control points lists, and sequences of operation are found on the Drawings. In the case of air-handling units and VAV air terminal units, points list, schematic diagrams, and sequences of operation shall be in complete and strict compliance with ASHRAE Guideline 36-2018 *High Performance Sequences of Operation for HVAC Systems*.
1. Air terminal units with reheat coils shall be controlled via dual-maximum sequence as detailed on the drawings or as specified in Guideline 36.
2. Air-handling unit static pressure reset shall be accomplished via trim-and-respond logic as detailed on the drawings or as specified in Guideline 36.

3. Air-handling unit supply air temperature reset shall be accomplished via trim-and-respond logic as detailed on the drawings or as specified in Guideline 36.
4. All air-side economizers shall be based on a fixed dry-bulb switchover point.

1.07 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
   1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, relays/switches, control panels, and operator interface equipment.
   2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
   3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

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. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   2. Schematic flow diagrams showing fans, coils, dampers, and control devices.
   3. Wiring Diagrams: Power, signal, and control wiring.
   4. Details of control panel faces, including controls, instruments, and labeling.
   5. Written description of sequence of operation.
   6. Schedule of dampers including size, leakage, and flow characteristics.
   7. Wiring diagrams for control units with termination numbers.
   8. Schematic diagrams and floor plans for field sensors and control hardware.
   9. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
   10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
   11. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
   12. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
   13. Written description of sequence of operation including schematic diagram.
   14. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135-2016, is BTL-Certified, and carries the BTL logo.

D. Samples for Initial Selection: For each color required, of each type of or sensor cover with factory-applied color finishes.

E. Samples for Verification: For each color required, of each type of sensor cover.

F. Software and Firmware Operational Documentation: Include the following:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.
   5. Software license required by and installed for DDC workstations and control systems.

G. Programming Software: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

H. Graphical User Interface: Submit an indexed list of screens and a flowchart representing hierarchical structure of menu navigation options.

I. Qualification Data: For installer, showing certification of manufacturer's completed training, hours of instruction, and course outlines.

J. Field quality-control test reports.

K. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
   4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5. Calibration records and list of set points.

L. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section "Basic Mechanical Requirements."

1.08 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project; and who has an established working relationship with the manufacturer of not less than three years.

B. Startup Personnel Qualifications: Engage specially-trained personnel in direct employ of manufacturer of primary temperature control system.

C. Programmer Personnel Qualifications: Engage specially-trained personnel in direct employ of manufacturer of primary temperature control system; whose primary office location is not more than 250 driving miles from the project site.

D. All 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.

E. BACnet Compliance: Comply with ASHRAE Standard 135-2016 for DDC system components and at all layers of system architecture. Each DDC system component shall be BTL-Certified and shall carry the BTL logo. All devices that control and/or monitor equipment shall support BACnet intrinsic reporting; and all devices that meet the B-ASC device profile requirements shall support BACnet intrinsic reporting.

1.09 REFERENCED STANDARDS

A. ANSI/ASHRAE Standard 135-2016: *BACnet - A Data Communication Protocol for Building Automation and Control Networks*, Atlanta, Georgia: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 2016, including BACnet Secure addendum.

B. Energy Compliance: ANSI/ASHRAE/IES Standard 90.1-2016 *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

C. Air Terminal Unit Controls: Test and rate air terminal unit controls in accordance with ANSI/ASHRAE 195-2013 *Method of Test for Rating Air Terminal Unit Controls*. This standard specifies instrumentation, facilities, test installation methods, and procedures for determining the accuracy and stability of airflow control systems for pressure independent terminal units at various airflow setpoints for variable-air-volume and constant-volume air-moving systems.

D. ASHRAE Guideline 36-2018 *High Performance Sequences of Operation for HVAC Systems,* Atlanta, Georgia: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 2018.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.11 COORDINATION

A. Coordinate location of exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Sections regarding Intrusion Detection to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 28 Sections regarding Fire Alarm to achieve compatibility with equipment that interfaces with that system.

D. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

E. Dedicated 20-amp / 120-volt AC (Standby, alternate only) Power circuit breakers are provided by Division 26 at Panel locations as shown on the Electrical Drawings. From that point, the party responsible for performance of this Section shall furnish, install, and connect all required power supply to all electric-powered control components. Furnish, install, and connect transformers as required to serve lower voltage and/or DC components. Perform field electrical work in complete and strict accordance with Division 26 requirements, the National Electric Code, and Part 3 of this Section.

F. Coordinate equipment with Division 26 Sections regarding Electrical Power Monitoring and Control to achieve compatibility of communication interfaces.

G. Coordinate equipment with Division 26 Sections regarding Panelboards to achieve compatibility with starter coils and annunciation devices.

H. Coordinate equipment with Division 26 Sections regarding Motor-Control Centers to achieve compatibility with motor starters and annunciation devices.

1.12 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents. In addition, warrant all work as follows.

B. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The contractor shall respond to the Owner’s request for warranty service within 24 hours during normal business hours.

C. All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up.

D. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies as identified by the contractor shall be provided at no charge during the warranty period. Any upgrades or functional enhancements associated with the above-mentioned items shall be offered and quoted to the Owner for consideration and possible acceptance.

1.13 OWNERSHIP OF PROPRIETARY MATERIAL

A. Ownership of Proprietary Material: All project-developed software and documentation shall become the property of the Owner, including but not limited to project graphic images, record drawings, project database, project-specific application programming code, and all documentation.

B. Licenses: All licenses associated with the control systems and its components will be for a duration of five (5) years and begin the same time as the final phase warrantee. After this period the Owner will be responsible for yearly licenses.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide DDC temperature control system (operator workstation software, controller software, custom application programming language, Building Controllers, Custom Application Controllers, Application Specific Controllers, and overall system architecture) by one of the following system manufacturers:
   1. Automated Logic Corporation
   2. Delta Controls Inc.
   3. Distech Controls
   4. Honeywell Building Solutions
   5. KMC Controls, Inc.
   6. Schneider Electric (Andover, I/A, and TAC brands).
   7. Trane Ingersoll Rand.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

C. Other products specified herein (e.g., sensors, dampers, and actuators) need not be manufactured by the above manufacturers, but they shall be fully integrated into the DDC temperature control system and warranted as if they were products of the above manufacturers.

2.02 DDC EQUIPMENT

A. System Backbone: A server and a universal software infrastructure shall allow building controls integrators, HVAC and mechanical contractors to build custom web-enabled applications for accessing, automating and controlling smart devices real-time via local network or over the Internet. Subject to compliance with requirements, provide an enterprise-level server with open communication protocol and with architecture by one of the manufacturers listed beneath the manufacturer heading above.

B. System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner’s local area network, and remotely over the Internet through the owner’s LAN).

C. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a Web browser shall be required to

access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.

D. Performance Monitoring. The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

E. Event Response. The BAS will provide the specified operational changes based on event response from the energy service provider.

F. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:
   1. System: Provide with at least one integrated USB 2.0 port, one integrated USB 3.0 port, one HDMI port, and integrated Intel Pro 10/100/1000 Mbps Ethernet network interface card.
   2. Processor: Intel Pentium i7, 1.8 GHz.
   3. Random-Access Memory: 8 GB or higher.
   4. Monitor: 17 inches (432 mm), minimum 1024 x 768 pixels.
   5. Keyboard: QWERTY 105 keys in ergonomic shape.
   6. Hard-Disk Drive: 1 TB minimum.
   7. Pointing Device: Touch pad or another internal device.
   8. Carrying case.

G. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
   1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse I/O.
      c. Monitoring, controlling, or addressing data points.
      d. Software applications, scheduling, and alarm processing.
      e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
   3. Standard Application Programs:
      a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, anti-short cycling, PID control, DDC with fine tuning, and trend logging.
      b. HVAC Control Programs: Optimal run time, supply-air temperature reset, and economizer switchover.
      c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
      d. Remote communications.
      e. Maintenance management.
      f. Units of Measure: Inch-pound and SI (metric).
   4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135-2016 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

H. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
   1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse I/O.
      c. Monitoring, controlling, or addressing data points.
   3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
   4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135-2016 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

I. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
   1. Binary Inputs: Allow monitoring of on-off signals without external power.
   2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
   3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
   4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
   5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
   6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
   7. Universal I/Os: Provide software selectable binary or analog outputs.

J. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
   1. Output ripple of 5.0 mV maximum peak to peak.
   2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
   3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

K. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
   1. Minimum dielectric strength of 1000 V.
   2. Maximum response time of 10 nanoseconds.
   3. Minimum transverse-mode noise attenuation of 65 dB.
   4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.03 APPLICATION SPECIFIC CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
   1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135-2016. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. Enclosure: Dustproof rated for operation at 32 to 120ºF (0 to 50ºC).

2.04 BUILDING CONTROLLER

A. Supports Gig-E, 1000 Mbps, BACnet IP and DHCP IP addressing.

B. Local Access Ethernet port at 100 Mbps for system start-up and troubleshooting.

C. Supports open protocols BACnet/IP, BACnet MS/TP, Lon Works, Modbus RTU, Modbus TCP.

D. All programming and historical data stored in non-volatile memory.

E. Real-time clock with capacitor backup.

F. Ability to communication up 64 application specific controls.

2.05 ENTERPRISE SERVER

A. 64-bit Dual core processor, 2G RAM 10 Mbps or higher LAN communication.

B. Windows Server 2016 or higher operating system.

C. Supports Transport Layer Security (TLS).

D. Built-in Fault Detention and Diagnostics (FDD).

E. Integration into other building systems and third-party software using BACnet, Modbus and other third-party open protocols.

F. Supports up to 50 simultaneous users.

2.06 INSTRUMENTATION ENVIRONMENTAL CONDITIONS

A. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

B. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.

C. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:
1. Outdoors, Protected: Type 3.
2. Outdoors, Unprotected: Type 4X.
3. Indoors, Heated: Type 2.
4. Indoors, Heated and Air Conditioned: Type 1.
5. Air-Moving Equipment Rooms: Type 2.
6. Localized Areas Exposed to Washdown: Type 4.
7. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.

8. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
9. Hazardous Locations: Explosion-proof rating for condition.

D. Test and inspect assembled instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

2.07 AIR AND DUCT TEMPERATURE SENSORS

A. Thermal Resistors (Thermistors) Common Requirements: Applicable to all types of thermistors.
1. 10,000 ohms at 25°C and a temperature coefficient of 23.5 ohms/ohm/°C.
2. Type 2.
3. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
4. Temperature Range: -50 to +275°F (-46 to +135°C).
5. Interchangeable Accuracy: At 77°F (25°C) within 0.5°F (0.3°C).
6. Repeatability: Within 0.5°F (0.3°C).
7. Drift: Within 0.5°F (0.3°C) over 10 years.
8. Self-Heating: Negligible.
9. Conduit Connection: ½-inch (16-mm) trade size.
10. Transmitter optional, contingent on compliance with end-to-end control accuracy.
11. Equivalent nickel RTDs and/or platinum RTDs meeting or exceeding the applicable performance requirements are also acceptable, but not mandatory, in lieu of thermistors throughout this Section.

B. Thermistor, Single-Point Duct Air Temperature Sensors:
1. Probe: Single-point sensor with a stainless-steel sheath.
2. Length: As required by application to achieve tip at midpoint of air duct, up to 18 inches (450 mm) long.
3. Enclosure: Junction box with removable cover.
4. Gasket for attachment to duct or equipment to seal penetration airtight.

C. Thermistor Averaging Air Temperature Sensors:
1. Multiple sensors to provide average temperature across entire length of sensor.
2. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
3. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
4. Length: As required by application to cover entire cross section of air duct.
5. Enclosure: Junction box with removable cover.
6. Gasket for attachment to duct or equipment to seal penetration airtight.

D. Thermistor Outdoor Air Temperature Sensors:
1. Probe: Single-point sensor with a stainless-steel sheath.
2. Solar Shield: Stainless steel.
3. Enclosure: Junction box or combination conduit and outlet box with removable cover and gasket.

E. Thermistor Space Air Temperature Sensors:
1. For use with DDC Controllers controlling terminal units.
2. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover or a flush, brushed-aluminum cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.
5. Pre-aged, burned in thermistor coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.

6. Provide digital display of sensed temperature.
7. Provide sensor with local override to turn HVAC on (manually over-ridable by control system operator).
8. Provide sensor with local adjustment of temperature setpoint (manually over-ridable by control system operator).
9. Insulating Bases: For sensors located on exterior walls.
10. Adjusting Key: As required for calibration and cover screws.

2.08 ELECTRONIC PRESSURE SENSORS AND SWITCHES

A. Duct Insertion Static Pressure Sensor: Non-directional sensor with suitable range for expected input, and temperature compensated; suitable for HVAC air duct applications.
   1. Insertion length shall be 4 inches (100 mm) for ducts up to 16-inches (400 mm) in dimension parallel to sensor; and 8 inches (200 mm) for larger ducts.
   2. Sensor with four radial holes of 0.04-inch (1-mm) diameter.
   3. Construct sensor of 6061-T6 aluminum alloy, Type 304 stainless steel, or brass.
   4. Sensor with threaded end support, sealing washers and nuts.
   5. Connection: Threaded, NPS 1/8 (DN 6) swivel fitting for connection to copper tubing or NPS ¼ (DN 10) barbed fitting for connection to polyethylene tubing.
   6. Mounting flange shall suitable for flat oval, rectangular, and round duct configurations.
   7. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   8. Output: 4 to 20 mA.
   9. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).

B. Outdoor Static Pressure Sensor: Sensor with no moving parts. Operation not affected and impaired by rain and snow.
   1. Sensing plates constructed of 0.1406-inch (3.6-mm) Type 316 stainless steel.
   2. Pressure Connection: Brass barbed fitting for NPS ¼ (DN 10) tubing.
   3. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.
   4. Accuracy within 1 percent of the actual outdoor atmospheric pressure when subjected to varying horizontal radial wind velocities up to 40 mph; within 2 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to 40 mph with approach angles up to 30 degrees to horizontal; and within 3 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to 40 mph with approach angles up to 60 degrees to horizontal.
   5. Threaded, NPS 2 (DN 50) connection.

C. Space Static Pressure Sensor: Aluminum or stainless-steel mounting plate with perforated center arranged to sense space static pressure. Exposed surfaces are provided with brush finish. Back of sensor plate shall be fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch (3-mm) fitting for tubing connection.
   1. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm (5.1 m/s) from a 360-degree radial source.
   2. Range: 0- to 0.25-inch wg (0 to 62 Pa).
   3. If Wall-Mounted: Wall plate provided with screws and sized to fit standard single-gang electrical box.
   4. If Recessed Ceiling Mounted: Sensor designed for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
   5. If Surface-Mounted: Surface-mounted sensor provided with solid mounting plate designed for mount to ceiling with pressure chamber exposed to view.
   6. If Suspended-Mounted: Suspended sensor designed for pendent mount with pressure chamber exposed to view.

D. Air-Pressure Differential Switch: Diaphragm operated to actuate an SPDT snap switch, and marked for intended location and application. If used for fan safety shutdown applications, the switch shall include manual reset.
   1. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
   2. Enclosure Conduit Connection: Knock out or threaded connection.
   3. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
   4. High and Low Process Connections: Threaded, NPS 1/8 (DN 6).
   5. Electrical Rating: 15A at 120- to 480-VAC.
   6. Pressure Limits: 45 inches wg (11.2 kPa) continuous and 10 psig (68.9 kPa) surge.
   7. Temperature Limits: -30 to +180°F (-34 to +82°C).
   8. Operating Range: Adjustable range of 0- to 5-inch wg (0 to 1240 Pa) unless noted otherwise.
   9. Repeatability: Within 3 percent.

E. Air Pressure Differential Transmitter: Include automatic zeroing circuit capable of automatically readjusting the transmitter to zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero
   1. Range: Approximately 2 times set point.
   2. Accuracy: Within 0.5 percent of the span at reference temperature of 70°F (21°C).
   3. Hysteresis: Within 0.02 percent of the span.
   4. Repeatability: Within 0.05 percent of the calibrated span.
   5. Stability: Within 0.25 percent of span per year.
   6. Overpressure: 15 psig (103 kPa).
   7. Temperature Limits: -20 to +160°F (-29 to +71°C).
   8. Compensate Temperature Limits: 35 to 135°F (2 to 57°C).
   9. Thermal Effects: 0.015 percent of full scale per °F.
   10. Warm-up Time: Within 5 seconds.
   11. Response Time: One second.
   12. Shock and vibration shall not harm the transmitter.
   13. Output Signals: Two-wire 4- to 20-mA dc current source signal capable of operating into 1000-ohm load; or three-wire 0 to 10 VDC with minimum load resistance of 1000 ohms.
   14. Operator Interface: Zero and span adjustments within 10 percent of full span. Potentiometer adjustments located on face of transmitter.
   15. Type 300 stainless-steel enclosure.
   16. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
   17. Screw terminal block for wire connections.
   18. Vertical plane mounting.
   19. Mounting Bracket: Appropriate for installation.
   20. Reverse wiring protected.
   21. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

2.09 STATUS SENSORS AND SWITCHES

A. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

B. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

C. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

E. Electronic Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.10 GAS DETECTION EQUIPMENT

A. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23º to 130ºF (-5º to +55ºC) and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output, for wall mounting.

2.11 DAMPERS

A. Dampers: See 233300 – Duct Accessories for damper requirements.

2.12 ACTUATORS

A. Manufacturers: Subject to compliance with requirements, provide damper actuators by Belimo Air controls USA, Inc. or approved equal.
   1. Damper Actuator Location: Install all damper actuators on outside of ducts in accessible locations; except that damper actuators installed outdoors exposed to outdoor weather shall be installed inside the duct with suitable access door adjacent. Access doors are specified in Division 23 Section “Duct Accessories.”

B. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action as indicated.
   1. Comply with requirements in Division 23 Section “Motors.”
   2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
   3. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
   4. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

C. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   1. Parallel-Blade Damper with Edge Seals: Size for running torque calculated based on 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
   2. Opposed-Blade Damper with Edge Seals: Size for running torque calculated based on 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
   3. Parallel-Blade Damper without Edge Seals: Size for running torque calculated based on 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
   4. Opposed-Blade Damper without Edge Seals: Size for running torque calculated based on 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
   5. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by multiplier of 1.5.
   6. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by multiplier of 2.0.
   7. Coupling: V-bolt and V-shaped, toothed cradle. Single bolt or set-screw type fasteners are not acceptable.
   8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

9. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): 24 or 120-Volt AC.
11. Power Requirements (Modulating): Maximum 10 VA at 24-Volt AC or 8 W at 24-Volt DC.
12. Proportional Signal: 2- to 10-Volt DC or 4 to 20 mA, and 2- to 10-Volt DC position feedback signal.
13. Temperature Rating: Minus 22º to plus 122ºF (Minus 30º to plus 50ºC).
14. Temperature Rating (Smoke Dampers): Minus 22º to plus 250ºF (Minus 30º to plus 121ºC).
15. Stroke Time: Not more than 120 seconds over full range.
16. External Direction-of-Rotation Switch.

2.13 POWER SUPPLY AND WIRING

A. The work of this section shall include providing all necessary temperature control power wiring except as otherwise described herein.

B. Dedicated 20-amp / 120-volt AC circuits are available at Panels indicated on E-series Drawings. From that point, the party responsible for performance of this Section shall furnish, install, and connect all required power supply to all electric-powered control components. Furnish, install, and connect transformers as required to serve lower voltage and/or DC components. Perform field electrical work in complete and strict accordance with Division 26 requirements and the National Electric Code.

C. Where current-sensing relays are specified or scheduled, the Division 26 installer will provide either a junction box in the power wiring between motor and starter, or space for same within the motor starter.

D. The work of this section includes installing the current-sensing relay, connecting the power wiring leads to same, and providing all control wiring.

E. All power wiring necessary for temperature controls operation not excluded above is the work of this Section.

F. Motor Control Relays: Square D 8501K relays or approved equal. Multi-pole switching applications at 120 volts; industry-standard wiring and pin arrangements; 15 A rated; DPDT; line-voltage throughput; AC or DC signal as compatible with temperature control signal. Provide where indicated via Equipment Data Schedule on the Drawings.

2.14 ELECTRONIC CABLE

A. Single-Conductor Coaxial: 50-ohm characteristic impedance, cellular polyethylene core, 97 percent coverage, bare copper-braid shield, PVC jacket; complying with MIL-C-17, Type RG-58/U.

B. Twin Lead: Bare copper-covered steel; 2-conductor parallel; 300-ohm characteristic impedance; polyethylene insulation and web between conductors; cellular polyethylene oval jacket.

C. Multi-conductor Cable: Quantity of conductors indicated; No. 18 AWG tinned-copper conductors; color-coded, low-loss PVC insulation; aluminum/Mylar shield; No. 22 AWG tinned-copper drain wire; PVC jacket.

D. Twisted Pair: Quantity of twisted pairs indicated; No. 22 AWG tinned-copper conductors; color-coded, PVC insulation; overall aluminum/polyester shield; No. 22 AWG tinned-copper drain wire; PVC jacket.

2.15 OPTICAL FIBER CABLES AND CONNECTORS

A. Cables: Factory-fabricated, single-channel, low-loss, glass-type, optical fiber, multimode, graded-index cables.

B. Construction: Single fiber with a 50-micron core diameter and a 125-micron cladding diameter, 250-micron outside-jacket diameter.

C. Ratings: 4.0-dB/850-nm maximum attenuation, 400-MHZ/km minimum bandwidth, 0.2 nominal numerical aperture.

D. Physical Characteristics: 7.5-kg/km, 500-N maximum installation load, 150-N maximum operational load, 30-mm minimum-bending radius.

E. Operating Temperature Range: Minus 20 to 70 C.

F. Optical Fiber Connectors: Stainless steel optical fiber cable connectors, capable of terminating optical fiber glass cables, with diameters ranging from 125 to 1000 microns. Fabricate connectors with optical fiber, self-centering, axial alignment mechanisms. Select resilient tip SMA-type connectors with quick-connect features and with insertion loss of not greater than 1.0 dB.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Examine roughing-in for instruments to verify actual locations of connections before installation.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTALLATION

A. Verify that power supply is available to control units and server.

B. Install software in control units and server. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

D. Verify location of exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above the floor. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install automatic dampers according to Division 23 Section “Duct Accessories.”

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Division 23 Section “Basic Mechanical Materials and Methods.”

H. Install products level, plumb, parallel, and perpendicular with building construction.

I. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.

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

K. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

L. Duct Pressure Sensors:
   1. Install sensors using manufacturer's recommended upstream and downstream distances.
   2. Unless indicated on Drawings, locate sensors approximately two-thirds of distance of longest hydraulic run.

3. Install mounting hardware and gaskets to make sensor installation airtight. Route tubing from the sensor to transmitter. Use compression fittings at terminations.
4. Install sensor in accordance with manufacturer's instructions.
5. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

M. Outdoor Pressure Sensors:
1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

N. Air-Pressure Differential Switches:
1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 (DN 12) tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet (15 m); otherwise, locate switch in vicinity of system connection.
9. Install devices in an easily accessible location serviceable from floor.

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

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

3.03 GRAPHICAL USER INTERFACE

A. Graphical User Interface shall consist of a turn-key installation on a Hosting Server capable of serving webpages to minimum of 50 computers via a popular web browser software such as Internet Explorer, Goggle Chrome, Mozilla Firefox and Safari.

B. Informational Screens shall consist of text, I/O points and software points to provide dynamic representations of equipment and control sequences. Point values and units shall be displayed

against a background that is representative of the applicable equipment or location containing the points.

C. Informational Screens shall be created for the following, where applicable:
   1. One home screen containing project identification, site plan and a critical information summary, including ambient conditions, presence of alarm conditions, summarized building conditions, and a Help screen.
   2. Individual floor-plans or project-specific areas.
   3. Individual equipment.
   4. Links to equipment Sequences of Operation.

D. Informational Screens or pull-down menus shall provide access to Schedule Management and Alarm Management.

E. Navigation: User logon shall automatically direct user to the home screen from which navigation to all Informational Screens shall be accessible. Navigational aids shall be consistent in appearance, location and function on all screens. Navigational aids can consist of traditional pull-down menus, or custom menus, such as menu trees, or screen buttons.

F. Screen Summaries: Where multiple areas, or similar pieces of equipment occur, summary screens shall be provided using a matrix format. Summary screens shall allow access to individual areas or equipment with minimal navigation.

3.04 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Furnish and install electrical power to products requiring electrical connections. Furnish and install circuit breakers. Install raceways, boxes, and cabinets according to Division 26 Section Sections. Install building wire and cable according to Division 26 Section Sections. Install signal and communication cable according to Division 27 Section Sections.
   1. Power wiring for Air Terminal Units with electric heating coils is the work of Division 26. Field-installed controls specified herein shall be installed and connected as the work of this section.

B. Conceal wire/cable and/or wire/cable raceway, except in mechanical rooms and areas where other conduit and piping are exposed.

C. All line-voltage wiring (greater than 24 Volts) shall be installed in raceway regardless of location or height.

D. All 24-Volt (and less) power, signal, and control wiring located above ceilings shall be installed in raceway or shall be plenum-rated cable meeting a 25/50 flame/smoke spread rating conforming to UL 910.
   1. Do not install low-voltage wiring in the same raceway as line-voltage wiring.
   2. Where plenum cables are used without raceway, support from structural members; do not support from ductwork, other electrical raceways, piping, or ceiling suspension system.

E. All power, signal, and control wiring located below ceilings, below the ceiling plane, or within walls shall be installed in raceway.

F. All power, signal, and control wiring in mechanical rooms and other rooms without finished ceilings shall be installed in raceway regardless of height.

G. Control wiring shall not be installed in the same conduit or raceway with power conductors. Where signal or control wiring is required (above) to be routed in raceway, provide a raceway separate from any raceway containing power wiring.

H. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

I. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Neatly tie and support conductors at 10-feet (3 m) intervals.

J. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

K. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

L. Unless noted otherwise, temperature controls functions shall be wired and connected to the AUTO leg of each respective equipment's HAND-OFF-AUTO selector switch at the respective motor starter. Connect HAND-OFF-AUTO selector switches to override automatic interlock controls when switch is in HAND position.
   1. Exception: Connect manual-reset limit controls and safety cutouts independent of manual-control switch positions.
   2. Automatic duct heater resets may be connected in interlock circuit of power controllers.

3.05 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 installation of air supply for each instrument.
   6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
   7. Check temperature instruments and material and length of sensing elements.
   8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
   9. Verify that DDC controller power supply is from emergency power supply, if applicable.
   10. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   11. Verify that spare I/O capacity has been provided.
   12. Verify that DDC controllers are protected from power supply surges.

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

3.06 CALIBRATION AND ADJUSTING

A. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance. Check out installed

products before continuity tests, leak tests, and calibration. Check instruments for proper location and accessibility.

B. Calibrate instruments. Make three-point calibration test for both linearity and accuracy for each analog instrument.

C. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

D. Control System Inputs and Outputs:
   1. Check analog inputs at 0, 50, and 100 percent of span.
   2. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
   3. Check digital inputs using jumper wire.
   4. Check digital outputs using ohmmeter to test for contact making or breaking.
   5. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

E. Flow: Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span. Manually operate flow switches to verify that they make or break contact.

F. Pressure: Calibrate pressure transmitters at 0, 50, and 100 percent of span. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

G. Temperature: Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source. Calibrate temperature switches to make or break contacts.

H. Adjust initial temperature set points.

I. Stroke and adjust control dampers without positioners, following the manufacturer's recommended procedure, so that damper is 100 percent open and closed.

J. Stroke and adjust control dampers with positioners, following manufacturer's recommended procedure, so that damper is 0, 50, and 100 percent closed.

K. Provide diagnostic and test instruments for calibration and adjustment of system.

L. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

M. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.07 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 Sections.
   1. Provide a total of 32 hours of onsite training at a minimum of two sessions. The sessions shall have a minimum separation of one month.
   2. Provide 40 hours of offsite classroom training for two people.

B. Perform field functional testing of the economizer for each air-handling unit, and complete Form NRCA-MCH-05-A NA7.5.4 *Air Economizer Controls Acceptance*. Submit the Certificate of Acceptance.

C. Record training videos on DVD disks. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and

troubleshooting. Owner shall have right to make additional copies of training DVD for internal use without paying royalties.

END OF SECTION

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes metal ducts and plenums for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round and flat-oval ducts and fittings.
   3. Sheet metal materials.
   4. Sealants and gaskets.
   5. Hangers and supports.
   6. Seismic-restraint devices.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 07 Sections “Penetration Firestopping” for fire-resistant sealants for use around duct penetrations and fire-damper installations in fire-rated floors, partitions, and walls.
   2. Division 08 Section “Access Doors and Frames” for wall- and ceiling-mounted access doors and for access to concealed ducts.
   3. Division 08 Section “Louvers and Vents” for intake and relief louvers and vents connected to ducts and installed in exterior walls.
   4. Division 23 Section “Mechanical Insulation.”
   5. Division 23 Section “Duct Accessories” for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
   6. Division 23 Section “Air Terminals” for temperature control terminal units.
   7. Division 23 Section “Diffusers, Registers and Grilles.”
   8. Division 23 Section “HVAC Instrumentation and Controls” for automatic control dampers and actuators.
   9. Division 23 Section “Testing, Adjusting and Balancing” for air balancing and final adjusting of manual volume dampers.

1.03 DEFINITIONS

A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C168.

1.04 PERFORMANCE REQUIREMENTS

A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by the design professional. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

B. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* and performance requirements and design criteria indicated in Part 3 of this Section.

C. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA *HVAC Duct Construction Standards – Metal and Flexible* and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Seismic force factors are specified in Division 13 Section "Seismic Restraints."

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2016.

1.05 SUBMITTALS

A. Product Data: For each type of the following products:
   1. Adhesives.
   2. Sealants and gaskets.
   3. Seismic-restraint devices.
   4. Manufactured ductwork and duct fittings (if applicable).
   5. MSDS (Material Safety Data Sheet) for each adhesive and sealant furnished.
   6. Sheet metal thicknesses.
   7. Joint and seam construction and sealing.
   8. Reinforcement details and spacing.
   9. Materials, fabrication, assembly, and spacing of hangers and supports.

B. LEED-NC v4 Submittals:
   1. Product Data for Prerequisite EQp1: Documentation indicating that duct systems comply with ASHRAE 62.1-2010, Section 5 – "Systems and Equipment."
   2. Product Data for Prerequisite EAp2: Documentation indicating that duct systems comply with ASHRAE 90.1-2010, Section 6.4.4 – "HVAC System Construction and Insulation."
   3. Leakage Test Report for Prerequisite EAp2: Documentation of work performed for compliance with ASHRAE 90.1-2010, Section 6.4.4.2.2 – "Duct Leakage Tests."
   4. Duct-Cleaning Test Report for Prerequisite EQp1: Documentation of work performed for compliance with ASHRAE 62.1-2010, Section 7.2.4 – "Ventilation System Start-Up."
   5. Product Data for Credit EQc2: For adhesives and sealants, including printed statement of VOC content.

C. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section "Basic Mechanical Requirements."

1.06 QUALITY ASSURANCE

   1. AWS D1.1/D1.1M, "Structural Welding Code – Steel," for hangers and supports.
   2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance: Comply with NFPA 90A-2018 *Standard for the Installation of Air Conditioning and Ventilating Systems*.

C. AMCA Compliance: All spiral ducts shall bear the AMCA Certified Ratings Program seal for Air Leakage.

D. Comply with NFPA 96 *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations* for range hood ducts, unless otherwise indicated.

E. ASHRAE Compliance: Applicable requirements in ASHRAE Standard 62.1-2016, Section 5 - "Systems and Equipment" and Section 7 – "Construction and System Start-Up."

F. ASHRAE Compliance: Applicable requirements in ASHRAE Standard 90.1-2016, Section 6.4.4 – "HVAC System Construction and Insulation."

1.07 REFERENCES

A. ANSI/SMACNA Standard 001-2008 *Seismic Restraint Manual; Guidelines for Mechanical Systems*, as published by the Sheet Metal and Air Conditioning Contractors National Association. 3rd ed. Chantilly, VA: SMACNA, 2008. All references to this document throughout this Section refer to this specific edition.

B. ANSI/SMACNA Standard 006-2006 *HVAC Duct Construction Standards – Metal and Flexible*, as published by the Sheet Metal and Air Conditioning Contractors' National Association. 3rd ed. Chantilly, VA: SMACNA, 2005. All references to this document throughout this Section refer to this specific edition.

C. ANSI/SMACNA Standard 016-2012 *HVAC Air Duct Leakage Test Manual*, as published by the Sheet Metal and Air Conditioning Contractors' National Association. 2nd ed. Chantilly, VA: SMACNA, 2012. All references to this document throughout this Section refer to this specific edition.

D. ACR 2006: National Air Duct Cleaners Association. *Assessment, Cleaning, & Restoration of HVAC Systems.* 4th ed. Washington, DC: NADCA, 2006. All references to this document throughout this Section refer to this specific edition.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Factory Pre-Insulated Duct Systems:
      a. Kingspan Insulation Ltd. (indoor ducts only)
      b. Thermaduct, LLC (outdoor ducts).
      c. or approved equal.
   2. Field-Applied Duct Sealant Materials:
      a. Ductmate, Inc.
      b. H.B. Fuller Construction Products Inc. (Childers and/or Foster brands)
      c. Hardcast, Inc.
      d. McGill Air Seal Corporation.
   3. Optional Manufactured Duct Slide-on Flange System:
      a. Ductmate, Inc.
      b. Nexus Inc.
      c. Ward Industries, Inc.
   4. Optional Round Duct Coupling System:
      a. Lindab, Inc. "Spirosafe"
      b. Sheet Metal Connectors, Inc.
      c. Spiramir Corp.
      d. Stamped Fittings Inc. "The Edge"

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653 / A653M.
   1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275).
   2. Finishes for Surfaces Exposed to View: Mill-phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008 / A1008M or ASTM A366 / A366M, cold-rolled sheets; commercial quality with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480 / A480M, Type 304 or 316, as indicated in Part 3 of this Section; cold rolled, annealed, sheet. Surface finish shall be No. 4 where exposed to view and No. 2B where concealed.

E. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A36 / A36M, steel plates, shapes, and bars; black and galvanized. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Comply with Articles 2.5 through 2.9, including all accompanying Tables and Figures, of the SMANCA HVAC Duct Construction Standards.

2.03 SEALANT MATERIALS

A. Two-Part Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal; Hardcast® Two-Part Sealing System, Uni-Cast® by McGill AirSeal Corporation, or equal.

B. One-Part Sealing System: Flexible, adhesive sealant, fiber-reinforced, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts. Examples of acceptable products include Uni-Mastic 181 by McGill, Foster 32-19, and Childers CP-146.

C. Water-Based Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

D. Formed-on Duct Connectors: Flange shop roll-formed onto edge of ductwork, with corner closures, cleats and gaskets for seal; TDC or TDF constructed per SMACNA T-25a or T-25b.
   1. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C920, Type S, Grade NS, Class 25, Use O.
   2. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.
   3. Contractor’s Option: Proprietary manufactured slide-on duct connectors by Ductmate, Ward, or Nexus meeting the above requirements will be accepted wherever formed-on duct connectors are required by these specifications.

2.04 RECTANGULAR DUCT FABRICATION

A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible*. Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, deflection limits, and joint types and intervals, except where more stringent requirements are specified herein.

B. All sheet metal shall be a minimum of 24-gage thickness in any case. Use 24-gage sheet metal where SMACNA allows thinner material.

C. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

D. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

E. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359-inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area, unless ducts are lined.

F. Pressure Classification: See Schedule in Part 3 of this Section.

G. Seal Classification: See Schedule in Part 3 of this Section.

H. Longitudinal Seams: Contractor's choice of Pittsburgh lock (SMACNA Figure 2-2 Type L-1) or Button Punch Snap Lock (SMACNA Figure 2-2 Type L-2) shall be used on all longitudinal seams. See "Seam and Joint Sealing" in Part 3 of this Section for further requirements.

I. Duct sizes shown on plans are free area sizes and do not include the thickness of internal duct liner, if any.

J. Contractor is free to alter the indicated sizes of rectangular duct to suit field conditions, provided that revised size is selected for friction loss no greater than that of indicated size. No prior approval by the Engineer is required for equal-friction duct size changes unless proposed size has an aspect ratio greater than 4 to 1.

K. All changes of direction shall be fabricated as elbows in accordance with SMACNA Figure 4-2 except that RE-4, RE-9 and RE-10 are prohibited. RE-6 is limited to a change-of-direction angle of 45 degrees or less.

L. Divided flow branches shall be Type 1 or Type 2 per SMACNA Figure 4-5. Type 3 divided flow branches are permitted only where expressly shown. Seek Engineer's approval of Type 3 where space and/or layout clearances prohibit Type 1 or Type 2.

M. Branch connections shall be per SMACNA Figure 4-6, except that straight taps are not permitted on any ducts 2-inch pressure class or above. Straight-tap "spin-in" fittings are permitted on ½-inch and 1-inch pressure class ductwork only.

N. Offsets and transitions shall be per SMACNA Figure 4-7, except that offset Type 2 (mitered) is limited to an angle of 45° or less.

O. Fittings at obstructions shall be per SMACNA Figure 4-8, except that Figure D is not permitted. Use Figure 4-8.B in lieu of Figure 4-8.D. Seek Engineer's approval of Figure 4-8.D where space and/or layout clearances prohibit use of Figure 4-8.B.

2.05 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Diameter as applied to flat-oval ducts in this Section is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Contractor's Option: The contractor is permitted to furnish spiral lock-seam round or flat-oval ductwork anywhere rectangular duct is indicated, provided the that adequate ceiling clearances and space required by other trades will permit round ductwork. If this option is chosen, round

duct sizes shall be selected by the Contractor according to “equal friction” with respect to the rectangular sizes shown.

C. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except that 26-gage is the thinnest material acceptable.

D. Longitudinal-seam round ducts (“stovepipe”) of a minimum 24-gage thickness, will be permitted on ½-inch and 1-inch pressure classifications only; and only if the Seal Class specified in Part 3 of this Section can be achieved.

E. Flat-Oval, Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except that 24-gage is the thinnest material available. With approval of Engineer, contractor may substitute flat oval duct where round duct is indicated, provided that revised size is selected for friction loss no greater than that of indicated size.

F. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible*, with metal thicknesses specified for longitudinal-seam straight ducts.

G. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

H. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1½ times duct diameter. Adjustable-angle elbow fittings are not permitted. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* unless otherwise indicated.
2. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
3. 90-Degree, 2-Piece, Mitered Elbows: Use only if approved by the Engineer where space restrictions do not permit using radius elbows. Fabricate with turning vanes.
4. Round Elbows 8 Inches (200 mm) and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
5. Round Elbows 9 through 14 Inches (225 through 355 mm) in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
6. Round Elbows Larger Than 14 Inches (355 mm) in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.

2.06 SHOP- AND FIELD-FABRICATED PLENUMS

A. Description: Provide galvanized steel (unless noted otherwise) air plenums in accordance with Chapter 9 of SMACNA *HVAC Duct Construction Standards – Metal and Flexible*. Air plenums required for this project include:

1. Outdoor air intake plenums for attachment to exterior outdoor air intake louvers, with connection point(s) for outdoor air duct(s). Construction shall be single wall with exterior insulation; coordinate size, orientation, and layout with Division 08 Section “Louvers and Vents” and the Drawings.

2. Exhaust air plenums for attachment to exterior exhaust louvers, with connection point(s) for exhaust air duct(s). Construction shall be single wall uninsulated; coordinate size, orientation, and layout with Division 08 Section “Louvers and Vents” and the Drawings.
3. Other HVAC plenums as indicated on Drawings.

B. Shop fabricate plenums to greatest extent possible with a minimum of joints and to minimize field fabrication and assembly.

C. Fabricate plenums with standing seam construction and angle reinforcement. Fabricate close-off sheets from plenum sides, top, and bottom to damper frames. Bolt close-off sheets to frame flanges and housings.

D. Fabricate plenums with sheet metal walls, top, and bottom panels. Do not use building walls, ceilings or floors as a portion of the plenum boundary, except where expressly shown on Drawings.

E. Reinforce plenums with galvanized or painted steel angles.

F. Seal joints as required in Part 3 of this Section.

G. Slope air plenums exterior louvers to fully drain so that any moisture that accumulates inside plenum drain to the outside.

H. Fabricate plenums with reinforced openings for access doors at least 18 inches (450 mm) wide by 24 inches (600 mm) high and located for access to each item of equipment housed. Each plenum shall have at least one access door; more if shown on Drawings. Refer to Division 23 Section “Duct Accessories” for access doors.

I. Mount automatic control dampers in air mixing plenums where applicable. Control dampers are supplied as the work of Division 23 Section “HVAC Instrumentation and Controls.”

2.07 FACTORY PRE-INSULATED DUCT AND FITTINGS

A. Contractor’s Option: For any ductwork specified to be field-insulated as identified in Division 23 Section “Mechanical Insulation,” the contractor shall be granted the option to install factory pre-insulated ductwork in lieu thereof, as specified in this sub-section.

B. To be considered acceptable, the factory pre-insulated duct system shall meet the same performance requirements specified for each application of traditional ductwork and duct insulation specified herein and in Division 23 Section “Mechanical Insulation,” including but not limited to the following characteristics:
1. R-value and thermal conductivity.
2. UL-723 25/50 Flame/Smoke rating.
3. UL-181 Class I air duct compliance.
4. Frictional losses, pressure classes, temperature and velocity limits.
5. Air leakage class and seal class ratings.
6. CFC/HCFC–free and zero Ozone Depletion Potential requirements.

C. The factory pre-insulated duct system shall include rigid phenolic insulation panels of minimum 29 psi (200 kPa) compressive strength. The rigid phenolic insulation panels shall comprise a closed-cell insulation core, auto-adhesively bonded on both sides to a 1 mil (25 micron) aluminum foil facing, reinforced with a 0.2-inch (5 mm) glass scrim, providing a 0.02-perm water vapor transmission rating.

D. All other components required for the fabrication of the factory pre-insulated duct system including, but not limited to, the silicone sealant, contact adhesive, aluminum tape, self–adhesive gasket, ductwork reinforcements, closures, connectors and flanges shall be as approved and/or supplied by the manufacturer.

E. The fabrication and installation of the factory pre-insulated duct system shall be carried out by a fabricator and installer that has successfully completed a specialist training course provided by the manufacturer.

F. Outdoor duct systems: In addition the above requirements, the factory pre-insulated duct system shall include the following features where installed outdoors exposed to weather: 39-mil UV-stable white vinyl outer shell with a minimum tensile strength of 6000 psi, encapsulating the entire system including fittings, couplings, and jointing hardware.

G. The factory pre-insulated duct system is not acceptable for use in the following applications:
   1. Kitchen exhaust.
   2. Where stainless steel and/or welded ductwork is specified.

2.08 HANGERS AND SUPPORTS

A. General: Support all ductwork in accordance with Chapter 5 of SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except where more stringent requirements are specified herein.

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
   2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Materials: Galvanized sheet steel or threaded steel rod. Primary duct hanger systems consisting of cable or wire are not acceptable; use steel angles, straps, and/or threaded rods.
   1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
   2. Strap and Rod Sizes: Comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

D. All supporting material surfaces in direct contact with supported ductwork (or flexible duct, or duct insulation, as applicable) shall be designed to maintain a minimum of one-inch (25 mm) contact width along full length of contact. Note that this precludes the use of wire systems (i.e., Gripple).

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes complying with ASTM A36.
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
   3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.09 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: As defined in Division 13 Section “Seismic Restraints.”

B. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips. Use ASTM A492, stainless-steel cables where attached to aluminum or stainless steel ducts.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Reinforcing steel angle clamped to hanger rod is also acceptable.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.01 DUCT PRESSURE CLASS SCHEDULE

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
   1. Constant-volume Supply Ducts: 2-inch wg (500 Pa).
   2. Variable-volume Supply Ducts upstream of VAV boxes: 3-inch wg (750 Pa).
   3. Variable-volume Supply Ducts downstream of VAV boxes: 1-inch wg (250 Pa).
   4. Return Ducts: 2-inch wg (500 Pa), positive or negative pressure as applicable.
   5. Transfer Ducts: 1/2-inch wg (125 Pa).
   6. Exhaust Ducts: 2-inch wg (500 Pa), positive or negative pressure as applicable.

3.02 DUCT MATERIAL SCHEDULE

A. All ducts shall be galvanized steel except as follows:
   1. Moisture-Laden Exhaust Ducts: Exhaust ducts originating from any room with showering facilities, for a minimum of 50 feet (or as shown on the plans), shall be fabricated of aluminum, with seams and laps arranged on top of duct.
   2. Grease Hood Exhaust Ducts: Comply with NFPA 96. Carbon-steel sheet of minimum thickness 0.054-inches if concealed; Type 304 stainless steel of minimum thickness 0.043-inches if exposed. Weld and flange seams and joints.
   3. Dishwasher Hood Exhaust Ducts: Aluminum if concealed, with seams and laps arranged on top of duct; Type 304 stainless steel if exposed, with welded or flanged seams and joints.

3.03 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible* unless otherwise indicated.

B. Install round and flat-oval ducts in lengths not less than 12 feet (3.7 m) unless interrupted by fittings.

C. Install ducts with fewest possible joints. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12-inches (300 mm), with a minimum of 3 screws in each coupling.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Install ducts with a clearance of 1-inch (25 mm), plus allowance for insulation thickness.

G. Duct sizes shown on plans are free area sizes and do not include the thickness of internal duct liner, if any.

H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

I. Install duct accessories as required by Division 23 Section “Duct Accessories.”

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Drawings are diagrammatic in nature. Not necessarily all fittings and offsets are shown. Provide all required fittings and offsets as required by field conditions and coordination with the work of other trades, whether specifically shown or not, for a complete and functional installation.

L. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

M. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

N. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1½ inches (38 mm).

O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section “Duct Accessories.” Firestopping materials and installation methods are specified in Division 07 Section “Penetration Firestopping.”

P. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic forces as further described in Division 13 Section “Seismic Restraints.”

Q. Protect duct interiors from the elements and foreign materials throughout construction. Follow SMACNA’s “Duct Cleanliness for New Construction.” Deliver ducts with shop-applied impervious protective covering over all open ends. Maintain protective end coverings through shipping, storage, and handling to prevent entrance of dirt, debris, and moisture. Elevate stored ducts above grade. As ductwork is installed, remove protective end covering as each successive segment is connected, but with protective end covering maintained over open ends remaining exposed.

R. Paint interiors of metal ducts for 24-inches (600 mm) upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

3.04 RANGE HOOD EXHAUST DUCTS, SPECIAL INSTALLATION REQUIREMENTS

A. Install ducts to allow for thermal expansion through 2000ºF (1110 C) temperature range.

B. Install ducts without dips or traps that may collect residues unless traps have continuous or automatic residue removal.

C. Install access openings at each change in direction and at intervals defined by NFPA 96; locate on sides of duct a minimum of 1½-inches (38 mm) from bottom; and fit with grease-tight covers of same material as duct.

D. Do not penetrate fire-rated assemblies except as permitted by applicable building codes.

3.05 SEAM AND JOINT SEALING SCHEDULE

A. General: Ducts noted as welded in the Duct Material Schedule above shall be made liquid-tight with all joints and seams full-penetration welded continuously along the entire length of the seam or joint. Otherwise, seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except where more stringent requirements are specified herein.

B. Seal externally insulated ducts before insulation installation.

C. Seal Class Schedule: Seal Class A and Leakage Class 6 is required for all ducts except as noted below.

1. Spiral lock-seams need not be sealed.
2. Transfer air ducts and transfer air boots need not be sealed.

D. Rectangular Duct: Sealant materials and methods shall be at contractor's option, chosen from among the products specified in Part 2 of this Section; provided that the above seal class and leakage class schedule is met.

E. Round or Flat Oval Duct: Transverse joints shall be made with a SMACNA RT-1 interior slip coupling beaded at center, fastened to duct with screws; in addition, apply Two-Part Sealing System continuously around exterior side of joint.
1. Contractor's Option: Furnish prefabricated round duct connection system consisting of self-sealing gasketed fittings. Round duct joints made with this type of fitting do not require the additional sealant specified above, provided that specified seal class is achieved.

3.06 HANGING AND SUPPORTING

A. Install rigid round, rectangular, and flat-oval metal duct with support systems indicated in SMACNA *HVAC Duct Construction Standards – Metal and Flexible.*

B. Support horizontal ducts within 24-inches (600 mm) of each elbow and within 48-inches (1200 mm) of each branch intersection.

C. Support vertical ducts at one- or two-story intervals (i.e., 12 feet (3.66 m) to 24 feet (7.32 m).

D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

E. Install concrete inserts before placing concrete.

F. Install powder-actuated concrete fasteners after concrete is placed and completely cured. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4-inches (100 mm) thick.

G. Repair any building insulation or building fireproofing materials, whether new or existing, that are removed or scraped away in order to attach hangers and supports, so as to maintain an equivalent insulation or fire rating as existed without said hanger or support attachment.

H. Provide seismic bracing and restraints as further described in Division 13 Section "Seismic Restraints."

3.07 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Duct Accessories."

B. Comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* for branch, outlet and inlet, and terminal unit connections.

3.08 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.
1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, condensate drain pans, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct accessories.
4. Clean coils and coil drain pans according to ACR 2006. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:
1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

END OF SECTION

SECTION 23 33 00
DUCT ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Manual volume dampers.
   2. Automatic control dampers.
   3. Fire dampers.
   4. Turning vanes.
   5. Duct-mounted access doors.
   6. Flexible connectors.
   7. Flexible ducts.
   8. Duct security bars.
   9. Duct accessory hardware.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 23 Section “HVAC Instrumentation and Controls” for actuators associated with automatic control dampers.
   2. Division 26 Section “Fire Alarm Systems” for duct-mounted fire detectors.

1.03 SUBMITTALS

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

B. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

C. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

A. Comply with NFPA 90A, “Installation of Air Conditioning and Ventilating Systems.”

B. Comply with AMCA 500-D testing for damper rating. All manufactured dampers of every type shall bear the AMCA Certified Ratings Program seal for Air Performance, Air Leakage, and Efficiency.

1.05 REFERENCED STANDARDS

A. Sheet Metal and Air Conditioning Contractors’ National Association. *HVAC Duct Construction Standards – Metal and Flexible.* 3rd ed. Chantilly, VA: SMACNA, 2005.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. HVAC Dampers (all types):

a. Air Balance Inc.; a division of Mestek, Inc.
b. Greenheck Inc.
c. Nailor Industries Inc.
d. Pottorff; a division of PCI Industries, Inc.
e. Ruskin Company.

2. Turning Vanes:
a. Ductmate Industries, Inc.
b. DuroDyne Inc.
c. Metalaire, Inc.
d. Semco Incorporated.
e. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

3. Duct-Mounted Access Doors:
a. American Warming and Ventilating; a division of Mestek, Inc.
b. Cesco Products; a division of Mestek, Inc.
c. Ductmate Industries, Inc.
d. Flexmaster U.S.A., Inc.
e. Greenheck Fan Corporation.
f. McGill AirFlow LLC.
g. Nailor Industries Inc.
h. Pottorff; a division of PCI Industries, Inc.
i. Ventfabrics, Inc.
j. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
k. Ruskin Company.

4. Flexible Connectors:
a. Ductmate Industries, Inc.
b. Duro Dyne Inc.
c. JP Lamborn Co.
d. Ventfabrics, Inc.
e. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

5. Flexible Ducts:
a. #087 by Atco Rubber Products, Inc.
b. Type 8M by Flexmaster USA, Inc.
c. “M-KE” by ThermaFlex.

2.02 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. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A653/A653M and having G60 (Z180) or G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2D finish for concealed ducts and No. 4 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), 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 B221 (ASTM B221M), Alloy 6063, Temper T6.

F. Minimum Thickness: All sheet steel used on this project shall be a minimum of 24-gage thickness, and all aluminum sheets shall be a minimum of 0.04-inch thickness, regardless of whether or not SMACNA standards permit thinner gage material.

G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

H. Tie Rods: Comply with Articles 2.5 through 2.9, including all accompanying Tables and Figures, of the SMANCA HVAC Duct Construction Standards.

2.03 MANUAL VOLUME DAMPERS

A. Manual volume dampers shall be standard leakage rating, with linkage outside airstream, suitable for horizontal or vertical applications. Volume dampers may be factory-manufactured or contractor-fabricated per SMACNA Fig. 7-4/7-5.

B. Material: Match material options throughout this subsection to the material of adjacent ductwork. For duct material, refer to Division 23 Section “Metal Ducts.”

C. Frames: Hat-shaped channels with mitered and welded corners, flanges for attaching to walls, and flangeless frames for installing in ducts.
   1. Galvanized-steel, 16-gage or 0.064-inch (1.62-mm) minimum thickness, for use in galvanized steel ducts.
   2. Aluminum sheet, 12-gage or 0.100-inch- (2.5-mm-) minimum thickness, for use in aluminum ducts.
   3. Stainless-steel, 16-gage or 0.064-inch (1.62-mm) minimum thickness, for use in stainless steel ducts.
   4. The above requirements may be reduced to 20-gage for round dampers installed in round ducts.

D. Blades: Multiple-blade; single-blade if duct dimension is 12-inch or less in the direction perpendicular to damper axis. Parallel or opposed-blade design (contractor’s choice, unless a specific type is indicated). Stiffen damper blades for stability.
   1. Galvanized-steel, 16-gage or 0.064-inch (1.62 mm) thick, for use in galvanized steel ducts.
   2. Roll-Formed Aluminum, 12-gage or 0.10-inch- (2.5-mm-) thick aluminum sheet, for use in aluminum ducts.
   3. Stainless-steel, 16-gage or 0.064-inch (1.62 mm) thick, for use in stainless steel ducts.
   4. The above requirements may be reduced to 20-gage for round dampers installed in round ducts.

E. Blade Axles: Galvanized steel, aluminum, or stainless steel, as required to match blade material. Dampers shall have axles full length of damper blades, and bearings at both ends of operating shaft.

F. Bearings: Oil-impregnated bronze, molded synthetic, and stainless-steel sleeve-type are acceptable.

G. Tie Bars and Brackets: Galvanized steel or aluminum.

H. Jackshaft:
   1. Size: 1-inch (25-mm) diameter.
   2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

I. Damper Hardware:
   1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a ¾-inch (19-mm) hexagon locking nut.

2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.04 AUTOMATIC CONTROL DAMPERS

A. Ultra Low-Leakage Class 1A rating, with linkage outside airstream. Subject to compliance with requirements, an example of an acceptable product is Ruskin Model CD-60.
   1. Leakage Rating: Maximum 3 cfm per square foot of damper area at 1-inch pressure when tested in accordance with AMCA Publication 500.
   2. Temperature Class: -40 to +200ºF.

B. Frames: 16 gage galvanized sheet steel frame formed into a structural hat channel reinforced at the corners; with mitered and welded corners.

C. Blades: Airfoil-shaped or triple-v-groove blades of galvanized steel construction.
   1. Multiple blade with maximum blade width of 6-inches (150 mm).
   2. Action: Parallel or opposed action as scheduled; opposed if not scheduled.
   3. Blade Edging: Closed-cell neoprene (Ruskiprene type or equivalent) edging, mechanically locked into blade edge.
   4. Blade Thickness: 14-gage or 0.079-inch (2.00 mm).

D. Blade Axles: ½-inch- (13-mm-) diameter; galvanized plated steel; square or hex-shape mechanically locked to blade; and blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

E. Bearings: High impact molded synthetic, or stainless-steel sleeve type, with thrust bearings at each end of every blade. Dampers shall have axles full length of damper blades and bearings at both ends of operating shaft.

F. Jamb Seals: Stainless steel flexible compression type.

G. Damper Motors: Furnished and installed as the work of Division 23 Section “HVAC Instrumentation and Controls.”

2.05 FIRE DAMPERS

A. Type: Dynamic; rated and labeled according to UL 555. Label according to UL 555C if used in a rated ceiling application.

B. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and 2000-fpm (10-m/s) velocity.

C. Fire Rating: 1½ hours.

D. Frame: SMACNA Type A, B or C as indicated; fabricated with roll-formed, 20-gage galvanized steel; with mitered and interlocking corners. If no indication is given, use Frame Type B for rectangular ducts and Frame Type C for round ducts.

E. Mounting Orientation: Vertical or horizontal as indicated.

F. Blades: Roll-formed, interlocking, galvanized sheet steel.

G. Horizontal Dampers: Include blade lock and stainless-steel negator closure spring.

H. Single-use Fusible Link: Replaceable, 165ºF (74ºC) rated, fusible links.

I. Mounting Sleeve: Factory-supplied, factory or field-installed, galvanized sheet steel sleeve; length as indicated. Include factory-supplied, field-installed two-piece “picture-frame” mounting angles with pre-punched fastener holes.
   1. Direct Grille Mounts: Where specifically indicated, furnish integral factory sleeve/ mounting angle assembly UL-listed for direct grille attachment.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

J. Multiple-Section Assembly: Where indicated fire damper size exceeds the maximum UL-approved dimensions of the manufacturer's UL-listed product line, provide multiple-section dampers including mullions and other hardware necessary for a UL-approved multi-section fire damper assembly.

2.06 TURNING VANES

A. All turning vanes, where required, shall be single-thickness type, 2-inch (50-mm) radius, 1½-inch (38-mm) spacing, at least 24-gauge thickness, and curved through an arc matching the change of direction (i.e., a vane curved through 90-degrees for a 90-degree elbow). Construct of material matching that of the adjacent duct (i.e., galvanized steel turning vanes in a galvanized steel duct, stainless steel turning vanes in a stainless steel duct, etc.).

B. Where two or more changes of direction occur with less than four duct widths (measured in the plane of the change of direction) between each elbow, each turning vane shall also include a straight trailing edge extension of 1-inch (25 mm). At contractor's option, all turning vanes may include this straight trailing edge extension even if not required.

C. Include vane rails or runners for attachment of vane blades to duct.

D. Either contractor-fabricated or factory-manufactured turning vanes meeting these specifications will be acceptable.

2.07 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Factory-manufactured doors, airtight and suitable for duct pressure class.

B. Door: Double wall, rectangular, galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.

C. Insulation: 1-inch (25-mm-) thick, fibrous-glass or polystyrene-foam board.

D. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.

E. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Number of Hinges and Locks: Two hinges, or continuous piano hinge, and two sash locks.

G. Size: 18 by 10-inches (460 by 250 mm) unless noted otherwise

2.08 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5¾-inches (146 mm) wide attached to 2 strips of 2¾-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

D. Fabric: Glass fabric double-coated with neoprene or polychloroprene. Fabric layers shall be shielded with metal on both sides at the seam, attached with a mechanical metal-to-fabric bond.
   1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
   3. Service Temperature: Minus 40 to plus 200ºF (Minus 40 to plus 93ºC).
   4. Insulated Service: Flexible ductwork connections shall be constructed of two layers of fabric as specified above, encapsulating 1-inch nominal thickness of R-4.2 fiberglass insulation. Required if the adjacent ductwork is specified to be insulated or internally lined.

5. Outdoor Service: Glass fabric shall be double-coated with weatherproof, synthetic rubber resistant to UV rays and ozone. Required if installed outdoors.

E. Thrust Limits: As specified in Division 23 Section “Mechanical Vibration Isolation.”

2.09 FLEXIBLE DUCTS

A. General: Comply with UL 181, Class 1. Factory-fabricated, insulated, round duct, with an outer jacket enclosing glass-fiber insulation around a continuous inner liner.
   1. Reinforcement: Galvanized steel wire helix encapsulated in inner liner.
   2. Outer Jacket: Polyethylene vapor-barrier film.
   3. Inner Liner: CPE film, acoustically transparent to mid-range sound energy.

B. Required Pressure Ratings:
   1. Sizes 12-inch and smaller: At least 8-inch wg positive and 1-inch wg negative.
   2. Sizes larger than 12-inch: At least 4-inch wg positive and ½-inch wg negative.
   3. Burst Rating: 2.5 times working pressure rating above.

C. Velocity Rating: 4000 fpm.

D. Temperature Rating: -20°F to +250°F.

E. Thermal Rating: Minimum R-4.2 thermal resistance.

F. Flexible Duct Connector Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18-inches, to suit duct size.

G. Provide flexible ducts with Flexflow elbow by Thermaflex for connections to air devices.

2.10 DUCT SECURITY BARS

A. Description: Factory-fabricated/field-installed or field-fabricated duct security bars.

B. Materials: See plans for details.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible.”

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 volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts.
   1. Locate dampers at least two duct diameters from fittings and as far away as possible from outlets.
   2. Install steel volume dampers in steel ducts.
   3. Install aluminum volume dampers in aluminum ducts.
   4. Install stainless steel volume dampers in stainless steel ducts.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire dampers according to UL listing.

G. Install duct security bars where indicated.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links.
   2. Downstream of in-duct coils.
   3. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Label access doors according to Division 23 Section “Basic Mechanical Materials and Methods” to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment using metal-edged connections or flanges.

L. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

M. Connect air devices to ducts with flexible duct clamped or strapped in place.

N. Connect air devices to ducts directly or with a minimum 36-inch (900-mm) and a maximum 60-inch (1500-mm) length of flexible duct clamped or strapped in place.

O. Install flexible ducts in accordance with the following:
   1. Turn radius of flexible duct at duct centerline shall not exceed one times nominal duct diameter.
   2. At least one support shall be installed for every run of flexible duct that is 60-inches (1500 mm) long or longer; more if needed to comply with next paragraph.
   3. Support flexible duct so that it does not contact nor rest upon light fixtures, sprinkler and other piping, ceilings and ceiling hanger wires, electrical conduits and cable tray, and similar items.
   4. All supporting material surfaces in direct contact with supported flexible duct shall maintain a minimum of one-inch in contact width along full length of contact.
   5. Comply with Figures 3-10 and 3-11 in SMACNA’s *HVAC Duct Construction Standards – Metal and Flexible.* 3rd ed. except where more stringent details are given on the Drawings.
   6. Comply with Specifications 3.5, 3.6, and 3.7, paragraphs S3.19 through S3.40, of SMACNA’s *HVAC Duct Construction Standards – Metal and Flexible.* 3rd ed., except where more stringent requirements are specified herein.

P. Install duct test holes where required for testing and balancing purposes.

3.02 FIELD QUALITY CONTROL

A. Operate dampers to verify full range of movement.

B. Inspect locations of access doors and verify that purpose of access door can be performed.

C. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.

D. Inspect turning vanes for proper and secure installation.

END OF SECTION

SECTION 23 34 23
FANS AND VENTILATORS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Centrifugal roof ventilators.
   2. Centrifugal roof ventilators for kitchen hood exhaust.
   3. Large ceiling fans.
   4. In-line centrifugal fans.
   5. Propeller fans.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 23 Section “Motors” specifies the motors required for use with fans.
   2. Division 23 Section “Mechanical Vibration Isolation” for vibration hangers and supports.
   3. Division 23 Section “Duct Accessories” for duct flexible connectors.
   4. Division 23 Section “HVAC Instrumentation and Controls” for control devices.
   5. Division 26 Section “Variable Frequency Drives” for variable speed motor controllers.

D. Products furnished, but not installed, under this Section include roof curbs for roof-mounted exhaust fans.

E. Stand-alone fans are specified herein. Refer to other Division 23 Sections for fans which are an integral part of packaged equipment.

1.03 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level, unless noted otherwise.

B. Operating Limits: Classify according to AMCA 99-16.

C. Fan Unit Schedule: The following information is specified in an equipment schedule on the Drawings.
   1. Fan performance data including capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
   2. Fan arrangement including wheel configuration, inlet and discharge configurations, and required accessories.

1.04 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.

7. Fan speed controllers.

C. 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.

D. Wiring Diagrams: Detail wiring for power and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For fans and ventilators to include in emergency, operation, and maintenance manuals.

G. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.05 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: All fans and ventilators shall bear the AMCA Certified Ratings Program seal for Air and Sound Performance.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

E. UL Listing: For kitchen grease exhaust applications, provide only fans which are specifically UL-Listed under UL 762 for the removal of smoke and grease laden vapors, tested and listed by UL to operate continuously at 300ºF and continue operation during grease flare-up test.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, if required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.07 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Sections.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS APPLICABLE TO ALL FANS AND VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide fans and ventilators by one of the following:
1. Acme Engineering & Mfg. Corp.
2. Big Ass Fans.
3. Carnes Company.
4. Epic Fans (Colossus).
5. Greenheck Inc.
6. Hartzell Fan, Inc.
7. JenCo Fan.
8. Loren Cook Company.

9. PennBarry, division of Air System Components.
10. Twin City Fan Company.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section "Basic Mechanical Requirements." Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product's shop drawing submittal.

C. Single Source: All fans of any given type shall all be provided by the same manufacturer.

D. Motors: Refer to Division 23 Section "Motors" for general requirements for factory-installed motors, whose requirements apply to the work of this Section as if fully repeated herein.
1. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.
2. Enclosure Type: Open drip-proof, where satisfactorily housed; guarded drip-proof, where subject to contact by employees, maintenance staff, or building occupants.
3. Motor Sizes: Minimum size as indicated, but larger if necessary so driven load will not require motor to operate in service factor range at design point, and larger if necessary so driven load will not require motor to operate beyond the service factor at any point on the fan curve.
4. Provide inverter-ready or inverter-duty motors with shaft grounding rings as specified in Division 23 Section "Motors" everywhere variable speed drives are indicated.

E. Disconnect Switch: Provide a factory-installed and pre-wired non-fused disconnect switch for all fans and ventilators, unless specifically noted otherwise.

F. Factory Finishes: Provide as follows.
1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly. Finish shall pass a 1,000-hour salt spray test conducted per ASTM B117 method.
3. Aluminum Parts: No finish required.

G. Explosion Proof Construction: Some fans are required to be explosion proof. See drawings for more information.

H. Sound-Power Level Ratings: Comply with AMCA 301-14 *Methods for Calculating Fan Sound Ratings from Laboratory Test Data*. Factory test fans according to AMCA 300-14 *Reverberant Room Method for Sound Testing of Fans*.

I. Wheel Balance: Factory-balance all fan wheels in accordance with AMCA Standard 204-05 (R2012) *Balance Quality and Vibration Levels for Fans*.

J. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to ASHRAE Standard 51-2016 (ANSI/AMCA Standard 210-2016) *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating*.

K. Fan Capacities and Characteristics: As scheduled on the Drawings.

2.02 CENTRIFUGAL ROOF VENTILATORS

A. Description: Centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
1. Provide direct-drive or belt-drive as indicated via Schedule on Drawings.
2. Provide upblast or down blast discharge as indicated via Schedule on Drawings.

B. Housing: Bolted and welded construction utilizing corrosion-resistant fasteners. Removable, spun-aluminum, dome top and outlet baffle constructed of 16-gauge marine alloy aluminum; bolted to a square, one-piece, aluminum base with venturi inlet cone. The aluminum base shall have continuously welded curb cap corners.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Kitchen Hood Exhaust Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains, and grease collector. Provide thermal insulating heat shield to protect motor and drive, comprised of minimum 1-inch thick, 2-pound density foil-faced fiberglass insulation.

C. Fan Wheels: Aluminum hub, inlet cone, and wheel with backward-inclined blades. Fan and motor shall be isolated from exhaust airstream in a weather-tight compartment.

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{10} of 40,000 hours.

F. Belt Drives: Precision-machined cast iron type, keyed and securely attached to the wheel and motor shafts; resiliently-mounted to housing, with final alignment and belt adjustment made after installation.
1. Service Factor Based on Fan Motor Size: 1.4.
2. Motor Pulleys: Adjustable pitch for use with motors through 5 horsepower; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.

G. Required Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, ½-inch (13-mm) mesh, aluminum or brass wire.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops. Minimum 16-gauge galvanized sheet steel frame formed into a structural hat channel reinforced at the corners; 14-gauge blades of galvanized steel. Stainless steel bearings. Neoprene or rubber blade edge seals mechanically locked into blade edge. Stainless steel flexible compression jamb seals. Linkage concealed in frame. Square or hex steel axles mechanically locked to blade.
5. Label: A UL-762 label is required where fans are designated for kitchen hood exhaust service.
6. Any other accessories as indicated via Schedule on Drawings.

H. Roof Curbs: Galvanized steel; mitered and welded corners; 1½-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1½-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Built-in cant and mounting flange.
2. Overall Height: 18 inches (450 mm).
3. Pitch Mounting: Manufacture curb to allow level fan mounting on a roof slope.
4. Metal Liner: Galvanized steel.
5. Mounting Pedestal: Galvanized steel with removable access panel.
6. Vented Curb: Unlined with louvered vents in vertical sides.

2.03 IN-LINE CENTRIFUGAL FANS

A. Description: In-line centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories. Provide direct-drive or belt-drive as indicated via Schedule on Drawings.

B. Housing: 18-gauge galvanized steel bolted construction, corrosion-resistant fasteners, access doors, straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side

wall, or ceiling mounting. Bolted access doors shall be provided on three sides, sealed with closed cell neoprene gaskets.

C. Fan Wheels: Aluminum, backward-inclined blades welded to cast aluminum hub.

D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{10} of 40,000 hours.

F. Required Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Companion Flanges: For inlet and outlet duct connections.
3. Vibration Isolators: Restrained spring isolators having a static deflection of 1 inch (25 mm).
4. Any other accessories as indicated via Schedule on Drawings

2.04 PROPELLER FANS

A. Description: Propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.
1. Provide direct-drive or belt-drive as indicated via Schedule on Drawings.
2. Provide intake or exhaust air direction as indicated via Schedule on Drawings.

B. Housing: 14-gauge galvanized steel wall panel with continuously-welded corners and integral venturi; with flanged edges and bolted construction using corrosion-resistant fasteners.

C. Fan Wheel: Replaceable, cast or extruded-aluminum blades riveted to a painted steel hub; factory set pitch angle of blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings of life ABMA 9, L_{10} of 40,000 hours.
4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 HP; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

E. Required Accessories:
1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: 12-gauge galvanized steel wire guard, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
5. Any other accessories as indicated via Schedule on Drawings.

2.04 CEILING FANS

A. General:

1. Fan Diameter: 12-feet.
2. Airflow (tested to ANSI/AMCA 230-23): 80,000 cfm.
3. Number of Fan Blades: Five.
4. Operating Temperature: 0°F to 122°F.
5. Acoustical Signature: Shall not exceed 55 dBA (measured 20 ft below and 20 ft from fan centerline in accordance with ANSI/AMCA 230-23).
6. Fan Construction:
   a. Extruded aluminum blades.
   b. Welded steel mounting frame and support assemblies.
   c. Unit ships ready for installation, no additional parts required.
7. Finishes:
   a. Anodized in accordance with MIL-A-8625
   b. Fan Blade Finish: Black Anodized Blades (Standard)], [Clear Anodized Blades], [Powder Coated Blades].
8. Support Frame: Welded A36 steel frame with powder coated finish.
9. Safety System: Structural steel mounting frame, ¼ dia steel wire rope, 1/8 dia steel wire rope (guy wires), structural steel blade struts, 1/8 dia steel wire rope blade lanyards and structural steel hub supports – top and bottom.
10. Gearbox: 2 stage helical, lifetime, lubrication completely sealed.
11. Identification: Attach to fan in conspicuous place stating:
    a. Capacity.
    b. Name of Manufacturer.
    c. Model Number.
    d. Serial Number.
12. Features:
    a. Infinite speed control to maximum operating speed.
    b. Reversing action.
    c. Integral redundant support features.
    d. Black anodized aluminum fan blades.
    e. Wall-mounted, multi-fan remote.

B. Electric Motor:
   1. See plans for horsepower, voltage, and phase.
   2. NEMA Rating: IP55.

C. VFD Assembly:
   1. VFD Voltage: See plans.
   2. Enclosure rating: NEMA 1.
   3. UL/CE rated variable frequency drive (VFD).
   4. Fused service disconnect in controller enclosure (Lock-out/Tag-out per OSHA).
   5. Solid state overload protection per NEC.
   6. CE compliant integral control wiring and EMI/RFI connectors. Shielded motor cable / remote wire / input filter on the VFD.
   7. UL VFD Assembly box pursuant to UL Code 508.

D. Remote Control Station:
   1. Fan speed control feature with infinite speed control from zero to maximum fan operating speed.
   2. Pass code protected.
   3. Reversing Switch.
   4. Enclosure rating: NEMA 1.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements of installation tolerances and other conditions affecting performance of the fans and ventilators. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install fans and ventilators level and plumb, and in accordance with manufacturer's written instructions.

B. Install fans and ventilators using vibration isolators. Vibration- and seismic-control devices are specified in Division 13 Section "Seismic Restraints" and Division 23 Section "Mechanical Vibration Isolation."

C. Roof-Mounted Fans: Place fan or ventilator onto roof curb and center. In cases where the gap between the 2 components is larger than ¾-inch (19 mm), install a wood filler strip on all 4 sides between the fan curb cap and the roof curb.
   1. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
   2. Positively attach roof-mounting fan's curb cap to the roof curb using a minimum of two lag screws, anchor bolts, or other suitable metal fasteners per side. Use cadmium-plated hardware of at least ¼-inch; larger if recommended by manufacturer.

D. See Division 23 Section "Basic Mechanical Materials and Methods" for additional anchorage and concrete base requirements.

E. Install units with clearances for service and maintenance.

F. Label units according to requirements specified in Division 23 Section "Basic Mechanical Materials and Methods."

3.03 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 Division 23 Section "Duct Accessories."

B. Coordinate ducts, pipes, conduit, and other work adjacent to fans and ventilators to allow service and maintenance clearance in accordance with manufacturer's installation instructions.

C. Connect wiring and ground equipment according to Division 26 Sections.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Testing, Adjusting and Balancing is the work of Division 23 Section "Testing, Adjusting, and Balancing", which shall include adjustment of fan to indicated rpm. After initial testing and balancing, the work of this Section shall include pulley/sheave replacement to meet operating conditions indicated. Remove, size, select, and install the proper pulley/sheave sizes, to match specified performance.
   1. Exception: Pulley/sheave replacement is not required for fans whose speed is controlled by a variable frequency drive, provided that specified performance can be met with speed controller at or below 100% output.
   2. Exception: Pulley/sheave replacement is not required where pulley/sheave is adjustable in pitch.

3.05 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.06 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Provide the services of a factory-authorized field service representative to inspect the installation of fans, including duct and electrical connections, and to report the results in writing. The field service representative shall perform, or shall witness the contractor’s performance of, 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 dampers in connected ductwork systems are in fully open position.
   9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
   10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   11. Shut unit down and reconnect automatic temperature-control operators.
   12. Remove and replace malfunctioning units and retest as specified above.
   13. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fans and ventilators. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

B. Review data in maintenance manuals. Refer to Division 01.

C. Schedule training with Owner, through Architect, with at least seven days' advance notice.

D. Demonstrate operation of fans and ventilators. Conduct walking tour of the Project. Briefly identify location and describe function, operation, and maintenance of each fan and ventilator.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Shutoff single-duct air terminal units.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. Related sections include Division 23 Section “HVAC Instrumentation and Controls” for control devices and installation associated with air terminals.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities; furnished specialties and accessories; shipping, installed, and operating weights; and sound-power ratings for each model indicated. Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.

B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Verify compliance with each third-party test or rating Standard referenced in the “Quality Assurance” subsection below.

D. LEED-NC v4 Submittal, Product Data for Prerequisite EQp1: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 – “Systems and Equipment.”

E. Wiring Diagrams: Detail wiring for power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

F. Field quality-control reports.

G. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include instructions for resetting minimum and maximum air volumes and for adjusting software set points.

H. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 23 Section “Basic Mechanical Requirements.”

B. Electrical Components, Devices, and Accessories: All terminals with electric-resistance heating coils specified in this section must be listed and labeled as a packaged assembly by Underwriters Laboratories or Environmental Testing Laboratories and bear the UL or ETL logo.

C. NFPA Compliance: Install air terminal units according to NFPA 90A-2015 *Standard for the Installation of Air Conditioning and Ventilating Systems*.

D. AHRI Certification: Only air terminals that are certified under the AHRI Standard 880-2017 Certification Program and carry the AHRI Seal will be accepted.

E. Controls: Test and rate air terminal unit controls in accordance with ANSI/ASHRAE 195-2013 *Method of Test for Rating Air Terminal Unit Controls*. This standard specifies instrumentation, facilities, test installation methods, and procedures for determining the accuracy and stability of airflow control systems for pressure independent terminal units at various airflow setpoints for variable-air-volume and constant-volume air-moving systems.

F. Control sequences shall be in complete and strict accordance with ASHRAE Guideline 36-2018 *High Performance Sequences of Operation for HVAC Systems*.

1.05 COORDINATION

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide Air Terminal Units by one of the following:
   1. Air System Components Inc. (Titus, Krueger, and Tuttle & Bailey brands).
   2. Carnes Co., Inc.
   3. Environmental Technologies, Inc.
   4. Hart & Cooley, Inc.
   5. Metalaire, div. of Metal Industries Inc.
   6. Price Industries Inc.
   7. Trane Technologies plc.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 AIR TERMINAL UNITS, GENERAL

A. Configuration: Pressure independent terminal unit as scheduled; including volume-damper assembly inside unit casing with control components located inside a protective metal shroud. Unit sizes, capacities, maximum and minimum airflows, maximum noise ratings, and maximum air pressure drops shall be as scheduled on the Drawings.

B. Casing: Minimum 22-gage galvanized steel or 0.032-inch (0.8-mm) aluminum.
   1. Air Inlets: Beaded round stub connection of length at least 2-inches beyond airflow sensor taps for inlet duct attachment.
   2. Air Outlets: Rectangular S-slip and drive connections.

C. Volume Damper: Minimum 22-gage galvanized steel with peripheral edge gasket and self-lubricating bearings. Include a mechanical hard stop to prevent over-stroking. Include permanent markings on damper shaft to indicate damper position by simple visual inspection.

D. Maximum allowable damper leakage is given below, when tested according to AHRI 880-2017, based on 4-inch wg (1000-Pa) differential static pressure (inlet to outlet) and 2500 fpm (12.7 m/s) air velocity at nominal box inlet diameter.
   1. 3% for nominal size 4-inch (100 mm).
   2. 2% for nominal sizes 5-inch (125 mm) through 7-inch (175 mm).
   3. 1% for nominal sizes 8-inch (200 mm) and larger.

E. Maximum allowable casing leakage is given below, when tested according to AHRI 880-2017, based on 3-inch wg (750-Pa) differential static pressure (inlet to outlet) and 2500 fpm (12.7 m/s) air velocity at nominal box inlet diameter.
   1. 3% for nominal size 4-inch (100 mm).
   2. 2% for nominal sizes 5-inch (125 mm) through 9-inch (225 mm).
   3. 1% for nominal sizes 10-inch (250 mm) and larger.

F. Airflow Sensor: Multipoint, multi-axis inlet velocity sensor with center-averaging feature, factory installed and connected to the controller with UL-listed fire-retardant pneumatic tubing. Single axis sensor is not acceptable for inlet diameters 6-inch and larger. The sensor shall output an amplified differential pressure signal that is at least 2.3 times the equivalent velocity pressure signal obtained from a conventional pitot tube. Balancing taps and airflow calibration charts shall be provided for field airflow measurements.

2.03 UNIT INSULATION

A. Fibrous-Glass Liner: All Air Terminal Units of all types shall include factory-installed internal liner. Comply with NFPA 90A and with NAIMA AH124 *Fibrous Glass Duct Liner Standard*.
   1. Materials: ASTM C1071 flexible bonded mat of dual-density glass fiber; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
   2. Thickness: ½-inch (13 mm) minimum; but thicker if required to meet specified or scheduled values for thermal and/or acoustic performance.
   3. Thermal Conductivity (k-Value): 0.26 at 75ºF (0.037 at 24ºC) mean temperature per ASTM C518.
   4. Moisture Resistance: Not more than 3% by weight at 120°F, 95% relative humidity. Insulation shall not support or promote mold or fungus growth per UL 181, ASTM C665, ASTM G21 and ASTM G22 tests.
   5. Performance: Rated for 5000 fpm, 150°F air temperature.
   6. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84.
   7. Liner Adhesive: Comply with NFPA 90A and with ASTM C916.

2.04 INTEGRAL ELECTRIC HEATING COILS

A. Electric Heating Coil: Comply with UL 1096. Flanged type, open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame; with integral control box factory prewired and installed. Include the following features:
   1. Primary over-temperature protection; disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.
   2. Secondary over-temperature protection; load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
   3. Minimum airflow proof switch for automatic shutdown upon inadequate airflow.
   4. Integral door interlock disconnect switch which prohibits access door from being opened while power is energized.
   5. Proportional SCR control of heat output.
   6. Fuses, for coils whose rated electrical current exceeds 48 Amps.

2.05 AIR TERMINAL UNIT CONTROLS

A. Direct Digital Controls: Bidirectional damper operator and microprocessor-based controller. Control devices shall be compatible with temperature controls specified in Division 23 Section “HVAC Instrumentation and Controls” and shall have the following features.

B. Damper Actuator: 24-Volt, powered closed, powered open, fail in last position unless noted otherwise. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.

C. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
   1. Occupied and unoccupied operating mode.
   2. Remote reset of airflow or temperature set points.
   3. Adjusting and monitoring with portable terminal.
   4. Dual maximum logic, in which the first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no higher than 95ºF while the airflow is maintained at the minimum (dead-band) flow rate; and the second stage of heating consists of modulating the airflow rate from the minimum (dead-band) flow rate up to the heating maximum flow rate.
   5. A fully-programmable zone controller, or a configurable controller with dual maximum logic pre-installed as described above. Configurable controllers without this feature will not be acceptable.
   6. The terminal unit controller shall convert the velocity pressure signal from the airflow sensor into an analog electronic control signal using a transducer and an analog-to-digital (A/D) converter.
   7. The controller shall be stable at a velocity pressure setpoint as low as 0.004 in. w.g. (1 Pa) using a 10-bit (or greater) A/D converter and a 0-1 in. w.g. (0-250 Pa) or 0-1.5 in. w.g. (0-375 Pa) range transducer.
   8. Fully compatible for two-way communication with temperature-control system specified in Division 23 Section “HVAC Instrumentation and Controls.”

D. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

E. Supply air temperature sensor: As specified in Division 23 Section “HVAC Instrumentation and Controls” and required for all Air Terminal Units.

F. Control Logic: Dual maximum as further specified in ASHRAE Guideline 36-2018 *High Performance Sequences of Operation for HVAC Systems*.

G. Test and rate air terminal unit controls in accordance with ANSI/ASHRAE 195-2013 *Method of Test for Rating Air Terminal Unit Controls.*

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Steel Cables: Galvanized steel complying with ASTM A603.

C. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

D. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

F. Requirements for Seismic Restraint: As described in Division 13 Section “Seismic Restraints.”

2.07 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

B. Verification of Performance: Test and rate air terminal units according to AHRI 880-2017 *Standard for Performance Rating of Air Terminals*.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install air terminal units level and plumb, according to manufacturer's written instructions, rough-in drawings, original design, and referenced standards. Maintain sufficient clearance for normal service and maintenance.

B. Protect all openings of air terminal units with filters or temporary covers throughout project storage, handling, and placement, to keep clean the interiors of air terminal units.

C. Terminal units shall be continuously insulated with thermal insulation and vapor barrier, in unbroken path from inlet duct through to outlet duct, so that no bare metal surfaces are left uninsulated. Field-insulate any portions of terminal unit if not factory-insulated, including but not limited to heating coil casing and duct inlet collar. Field insulation and vapor barrier are specified in Division 23 Section "Mechanical Insulation."

D. After completing system installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes. Vacuum clean the interior of air terminals if the openings were not protected during construction.

3.02 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.03 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes, as further described in Division 13 Section "Seismic Restraints."

B. Install seismic-restraint devices for air terminal units using ANSI/SMACNA Standard 001-2008 *Seismic Restraint Manual; Guidelines for Mechanical Systems*, as issued by the Sheet Metal and Air Conditioning Contractors National Association, Inc., 2008; Chantilly, Virginia; Third Edition.

3.04 MECHANICAL CONNECTIONS

A. Ductwork: Connect ductwork to air terminals according to Division 23 ductwork Sections and Details on Drawings.

3.05 ELECTRICAL CONNECTIONS

A. Power, signal, and control wiring for cooling-only Air Terminal Units and/or Air Terminal Units with hydronic heating coils is the work of Division 23 Section “HVAC Instrumentation and Controls.”

B. Power wiring for Air Terminal Units with electric heating coils is the work of Division 26. Field-installed controls specified herein shall be installed and connected as the work of Division 23 Section “HVAC Instrumentation and Controls.”

3.06 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section “Basic Mechanical Materials and Methods” for equipment labels and warning signs and labels.

3.07 FIELD QUALITY CONTROL

A. Complete installation and startup checks according to manufacturer’s written instructions, and perform the following field tests and inspections:
   1. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
   2. Verify that controls and control enclosure are accessible.
   3. Verify that control connections are complete.
   4. Verify that nameplate and identification tag are visible.
   5. Verify that controls respond to inputs as specified.
   6. After installing air terminal units, and after electrical circuitry (where applicable) has been energized, test for compliance with requirements.
   7. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

C. Engage a factory-authorized service representative to train Owner’s maintenance personnel in proper adjustment, operation, troubleshooting, and maintenance of air terminal units. Refer to Division 01 for requirements.

END OF SECTION

SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 08 Section “Louvers and Vents” for fixed and adjustable louvers and wall vents installed in exterior walls, whether or not they are connected to ducts.
   2. Division 23 Section “Duct Accessories” for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
   3. Division 23 Section “Testing, Adjusting, and Balancing” for balancing diffusers, registers and grilles.

1.03 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.04 SUBMITTALS

A. Product Data: For each 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. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.05 QUALITY ASSURANCE

A. Testing: Test and publish performance according to ANSI/ASHRAE Standard 70-2006 *Method of Testing the Performance of Air Outlets and Air Inlets*.

B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A-2015 *Standard for the Installation of Air-Conditioning and Ventilating Systems*. Where located less than 84 inches above finish floor, diffusers, registers and grilles shall be designed to prohibit passage of a ½-inch sphere.

C. Single-Source: Unless noted otherwise, a single manufacturer shall furnish all diffusers, registers, and grilles.

PART 2 - PRODUCTS

2.01 COMMON REQUIREMENTS, ALL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air System Components Inc. (Titus, Krueger, and Tuttle & Bailey brands).
   2. Carnes Co.
   3. Hart & Cooley, Inc.
   4. Metalaire, Inc.; Metal Industries Inc.
   5. Nailor Industries, Inc.
   6. Price Industries.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

C. Diffusers, registers, and grilles are scheduled on Drawings. All model numbers, finish designations, border types, and accessory designations are based one manufacturer identified therein. Products by other manufacturers listed above may be furnished, but must be equal in all respects to the device identified, including but not limited to NC, pressure, and cfm ratings.

D. Diffusers, Registers, and Grilles Finish: Acrylic baked enamel paint, pencil hardness HB to H, color as scheduled. The finish shall pass a 250-hour ASTM 870 Water Immersion Test, a 100-hour ASTM D117 Corrosive Environments Salt Spray Test, and a 50 inch-pound ASTM D2794 Reverse Impact Cracking Test.

E. Integral Balancing Damper: Where dampers are scheduled as an integral part of diffusers and grilles (registers), provide multi-blade gang-operated opposed-blade type, radial-style if used with round ducts; 24 gage galvanized steel, except that aluminum dampers shall be used with aluminum diffusers and registers. Integral dampers shall be operable from the room side of the diffuser or register without special tools.

F. Diffusers, Registers, and Grilles Mounting: Provide border frame mounting type as scheduled. If not scheduled, provide border frame mounting type compatible with ceiling or wall type indicated on Architectural Drawings. Distinguish between flush flat-tee lay-in ceilings, drop-face lay-in ceilings, and the narrow-tee or screw-slot lay-in ceilings by providing a border type specifically designed for each as applicable; a generic standard lay-in border frame will not be acceptable for multiple lay-in ceiling types.

G. Seismic Restraint: Earthquake ceiling tabs are required on all diffusers, registers, and grilles installed in a lay-in ceiling, to provide positive connection of air device to ceiling runners. Refer to Division 13 Section “Seismic Restraints” for additional seismic requirements.

2.02 PRODUCT SPECIFICATIONS

A. Square Plaque Ceiling Diffuser: 22-gage steel (use 0.040-inch aluminum where scheduled) face panel that captures a secondary panel of equal material and thickness. The face panel shall be removable via four hanger brackets. The exposed surface of the face panel shall be smooth, flat, and free of visible fasteners. The face panel shall project not more than ¼-inch below the outer border of the diffuser back pan. The back of the face panel shall have a rolled edge, shaped for horizontal discharge. Face panel shall be no smaller than 18-inch by 18-inch for diffusers nominally 24-inch by 24-inch. Face panel shall be no smaller than 9-inch by 9-inch for diffusers nominally 12-inch by 12-inch. The back pan shall be one-piece die-stamped and include an integrally drawn inlet (welded-in inlets and corner joints are not acceptable). Include a diffuser neck of minimum 1¼-inch depth for connection and attachment of round or rectangular (as scheduled) duct.

1. Where noted on the plans, include round damper constructed of heavy gauge steel. Damper shall be operable from the face of the diffuser.
2. Include directional blow clips to restrict the discharge air in certain directions.
3. Include molded insulation blanket of R-6, foil-backed. Provide an additional 1-inch gap around the neck to install insulated flex duct.
4. Where an aluminum diffuser is indicated by Schedule or note, the entire product shall be constructed of aluminum, including but not limited to face plate, pattern controllers, border, back pan, neck, collar, etc.

B. Standard-Performance Grille: Adjustable double-deflection supply grilles, single fixed deflection return grilles, of sizes and performance as scheduled. Blades shall be 24-gage steel; supply grille blades shall be individually adjustable and held in place without rattling or slip by tension wire or metal friction pivots. Frame shall be roll-formed 24-gage steel or with 1-inch minimum flange and full penetration welds at the corners. Exposed screw holes shall be countersunk for flush finish surface.

C. Heavy-Duty Grille: Adjustable double-deflection supply grilles, single fixed deflection return grilles, of sizes and performance as scheduled. Blades shall be 14-gage steel; supply grille blades shall be individually adjustable and held in place without rattling or slip by tension wire or metal friction pivots. Frame shall be roll-formed 18-gage steel or with 1-inch minimum flange and full penetration welds at the corners. Exposed screw holes shall be countersunk for flush finish surface.

D. Corrosion-Resistant Grille: Adjustable double-deflection supply grilles, single fixed deflection return grilles, of sizes and performance as scheduled. Blades shall be 24-gage Type 304 stainless steel; supply grille blades shall be individually adjustable and held in place without rattling or slip by tension wire or metal friction pivots. Frame shall be roll-formed 24-gage Type 304 stainless steel or with 1-inch minimum flange and full penetration welds at the corners. Exposed screw holes shall be countersunk for flush finish surface.

E. Security Diffuser, Register, or Grille: All stainless steel assembled and welded construction with the outer perimeter (face flange) formed to raise the grille from the wall. The edge of the face flange shall be manufactured with a beveled slope with no open or unfinished edges. The edge shall rest flat on the wall.
   1. Security Level: Minimum security.
   2. Material Thickness: 12-gauge steel.
   3. Face Arrangement: 13/16” square holes on 1” centers.
   4. Mounting: Tamper-proof screws through face.

F. Other grilles, registers and diffusers not specified above may be specified on the Drawings or by virtue of make and model number on the Schedule.

2.03 FIELD-PROVIDED ACCESSORIES

A. Sight/Sound Screen: Provide contractor-fabricated galvanized steel return air screen or boot for all unducted return air grilles or sections of the diffuser used for unducted return air, as detailed on the Drawings.

B. Other accessories may be required by virtue of notations on the Schedule or as detailed on the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Install diffusers, registers, and grilles level and plumb.

C. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

E. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

F. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION

SECTION 23 41 00
AIR FILTERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used for HVAC applications.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
   1. Submit documentation indicating that units comply with ASHRAE 62.1, Section 5 - “Systems and Equipment.”
   2. Submit product data for adhesives and sealants, including printed statement of VOC content.

B. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals specified in Division 23 Section “Basic Mechanical Requirements.”

C. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

A. Comply with NFPA 90A.

B. ASHRAE Compliance: Comply with provisions of ANSI/ASHRAE 52.2-2017 for method of testing and rating air-filter units. The term “MERV” as used herein is defined by ANSI/ASHRAE Standard 52.2-2017 *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*.

C. ASHRAE Compliance for Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2016.

D. Comply with ANSI/AHRI 850-2013 *Performance Rating of Commercial and Industrial Air Filter Equipment*.

1.05 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.

B. Provide two complete sets of filters for each filter bank, in addition to the initial set. The initial set shall be used to protect the ductwork and equipment during construction. The second set shall be installed by the Contractor upon Final Completion of the project. The third set shall be turned over to the Owner for use as spares.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Air Filters: Subject to compliance with requirements, provide particulate air filters by one of the following:
   1. AAF International
   2. Airguard Industries, Inc.
   3. Barnebey - Sutcliffe Corp.
   4. Farr Co.
   5. Koch Filter Corp.

B. Filter Gages: Subject to compliance with requirements, provide diaphragm-type filter bank gages by one of the following:
   1. Airguard Industries, Inc.
   2. Dwyer Instruments, Inc.

C. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 MERV-8 PARTICULATE AIR FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames. Rigid, 1-inch, 2-inch, or 4-inch thickness as indicated, MERV-8.

B. Entire filter shall be legally disposable in landfills under the regulations of the authority having jurisdiction.

C. Media: Non-woven cotton fabric type. Media shall be bonded to frame to prevent air bypass.
   1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Separators shall be bonded to the media to maintain pleat configuration.
   3. Welded wire grid shall be on downstream side to maintain pleat, with an effective open area of not less than 96%, bonded to the filter media.
   4. Support members on upstream and downstream sides to maintain pleat spacing.
   5. At least 2.4 square feet of effective media area per square foot of filter face area and not less than 15 pleats per linear foot (for 1-inch nominal thickness).
   6. At least 4.2 square feet of effective media area per square foot of filter face area and not less than 15 pleats per linear foot (for 2-inch nominal thickness).
   7. At least 6.9 square feet of effective media area per square foot of filter face area and not less than 11 pleats per linear foot (for 4-inch nominal thickness).

D. Frame: Rigid, heavy-duty, high wet-strength beverage board with diagonal support members bonded to both sides of each pleat. Bond frame to outer periphery of filter pack to prohibit air bypass.

E. Filter Unit Class: UL 900, Class 1 or 2.

2.03 MERV-13 PARTICULATE AIR FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames. Rigid, 12-inch thickness, MERV-13.

B. Entire filter shall be legally disposable in landfills under the regulations of the authority having jurisdiction.

C. Media: High-density microfine glass fibers, laminated to a non-woven synthetic backing to form a lofted filter blanket.
   1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Separators shall be bonded to the media to maintain pleat configuration.
   3. Welded wire grid shall be on downstream side to maintain pleat, with an effective open area of not less than 96%, bonded to the filter media.
   4. Media shall be bonded to frame to prevent air bypass.
   5. Support members on upstream and downstream sides to maintain pleat spacing.

D. Frame: Rigid, galvanized steel with diagonal support braces and lateral contour stabilizers bonded to both sides of each pleat. Bond frame to outer periphery of filter pack to prohibit air bypass. Frame shall withstand 2 times highest cataloged final pressure resistance without discernable deflection of the frame or media pack.

E. Filter Unit Class: UL 900, Class 1 or 2.

2.04 FILTER GAGES

A. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment; Dwyer Magnehelic® or approved equal.
   1. Diameter: 4-inches.
   2. Range: 0- to 3.0-inch wg.
   3. Housing: Die cast aluminum case and bezel, with acrylic cover.
   4. Ratings: 15 psig and 140°F.
   5. Accuracy: ±3% of full scale throughout range at 70°F.

B. Required Accessories: Static pressure tips, tubing, gage connections, and mounting bracket.

C. In addition to the above locally-read gage, one or more remote-reading filter bank pressure gages may be required as part of Division 23 Section “HVAC Instrumentation and Controls.” If so, it does not satisfy the requirement for a locally-read gage.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install filters in position to prevent passage of unfiltered air.

B. Install filter gage at each air handling unit (AHU) filter bank.

C. Install filter-gage static-pressure tips upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

D. Coordinate filter installations with ductwork and air-handling unit installations.

E. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

F. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.

3.02 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Air filter will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.03 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-distribution systems, clean filter housings and install new (second set) of filter media.

END OF SECTION

SECTION 23 55 23
INDIRECT GAS-FIRED RADIANT HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes low-intensity, indirect gas-fired tubular, modulating radiant tube heaters.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 20 Section “Seismic Protection” for seismic requirements.
   2. Division 22 Section “Natural Gas Piping” for fuel supply to gas-fired radiant heaters.
   3. Division 23 Section "Basic Mechanical Requirements” for general requirements.
   4. Division 23 Section “Basic Mechanical Materials and Methods” for general requirements.
   5. Division 23 Section “Hangers and Supports” for supports, product descriptions, and installation requirements.
   6. Division 23 Section “HVAC Instrumentation and Controls” for temperature control components associated with gas-fired radiant heaters.

1.03 SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Include plans, elevations, sections, and mounting or attachment details.
   3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Include diagrams for power, signal, and control wiring.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's special warranties.

D. Operation and Maintenance Data: For gas-fired, radiant heaters to include in emergency, operation, and maintenance manuals.

E. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

A. Gas-Fired Radiant Heaters shall be UL-listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.

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

1.05 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period starting from date of Substantial Completion.
   1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.
      a. Burner Controls: Three years.
      b. Combustion and Heat Exchanger Tubes: Ten years.

PART 2 - PRODUCTS

2.01 INDIRECT GAS-FIRED RADIANT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advanced Radiant Systems.
   2. Reznor.
   3. Schwank.
   4. Solaronics.
   5. Space-Ray.
   6. Superior Radiant Products Ltd.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

C. Description: Factory-assembled, indoor, overhead-mounted, electrically controlled, low-intensity, infrared, adaptive modulating, radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup. Unit shall have a radiant coefficient greater than 80% and thermal efficiency greater than 90% verified by an independent qualified testing laboratory.

D. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at project site.

E. Assemblies: Assemblies shall be CSA approved. Low intensity heaters to ANSI Z83.20 (latest revision) and CSA 2.34 (latest revision) for use in commercial and industrial applications.

F. Code Compliance: Installations of units shall comply with local building codes, or in their absence, the latest edition of the national regulations and procedures listed below:
   1. Electrical: heaters shall be electrically grounded in accordance with the National Electric Code, ANSI/NFPA 70.
   2. General Installation and Gas Codes: Heaters shall be installed only for use with the type of gas appearing on the rating plate, and the installation shall conform to the National Fuel Gas Code, ANSI Z223.1 (NFPA 54).
   3. Venting: Refer to the National Fuel Gas Code, ANSI Z223.1 (NFPA 54), for proper location, sizing and installation of vents as well as information on termination clearance requirements when penetrating combustible walls for venting purposes.

G. Burner Control:
   1. Each burner shall employ a two-stage burner; burner shall extend into the combustion chamber. Burner head designed to deliver a low turbulent supply of fuel air mixture for delivery of a longer flame.
   2. A self-checking pressure differential switch shall be located in each burner unit to prevent activation on loss of combustion air flow.

3. The burner combustion chamber shall be isolated from the control compartment to prevent combustion air from being drawn across the controls.
4. Ignition system shall be Direct Spark Igniter (DSI) with flame rectification sensor, with a three-try, 15 second trial for ignition then lockout control.
5. Indicator lights shall be located at the back of burner cabinet to indicate “Low Fire” and “High Fire”.
6. Electrical ratings: See plans.

H. Burner Safety Controls:
1. Gas Control Valve: 24-V ac gas valve containing solenoid valve, electric gas valve, pressure regulator, and manual shutoff all in one body.
2. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.

I. Combustion and Radiant Pipe:
1. Both the combustion pipe and radiant pipe shall be 4” diameter, 16 gauge colorized aluminized steel for the entire length of tubing contained in each unit.
2. Tubing Connections shall be aluminized-steel couplings with draw tight band clamps.

J. Vent or Tail Pipe:
1. Flue pipe shall be of the size and length as indicated on the drawings. Pipe and fittings to be constructed of 4” or 6” (see plans for size) polypropylene pipe (high efficient, condensing systems).
2. Vacuum Fan (when required, per system layout and design).
   a. Electrical ratings: See plans.
   b. The pump shall be capable of discharging either vertically or horizontally. Blower housing and wheel to be constructed of cast aluminum.
   c. The flexible connector connecting the fan to the exhaust manifold shall withstand a temperature of not less than 350° F.
   d. Sidewall or horizontal exhaust shall be terminated with a sidewall hood by Tjernlund VH Series designed for horizontal discharge constructed of a non-corrosive material.
   e. Vertical discharge shall be constructed of stainless steel with double wall construction where penetrating through roof. Install a tee with condensate trap at the bottom of the riser.
   f. Pipe condensates drain to a location acceptable to codes and policies.

K. Reflectors:
1. Primary Reflector shall be constructed of polished aluminum with 100% Reflection to the floor and have 100% efficient reflective shape.
2. Secondary Canopy Reflector shall be constructed of 24-gage aluminized steel.
3. Reflectors shall be supported by means of a 1” box iron welded bracket which will surround the reflector and tubes.
4. Reflectors shall be secured into place with bolts and self-locking nuts.
5. Provide 100 percent reflectivity, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Provide for rotating reflector or heater around a horizontal axis for minimum 30-degree (0.52-radian) tilt from vertical.
6. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees (0.52 radians) from vertical.

L. Recuperative Heat Exchanger:

1. The infrared radiant heater will include a recuperative heat exchanger. The heat exchanger will preheat the combustion air by recovering heat from the flue gases. Provide a combustion air and a burner fan to ensure proper unit operation.
2. This unit must be approved by the CSA as an integral part of the heater.
3. The heater exchanger will be constructed from extruded aluminum which has been designed to maximize the heat transfer between the flue products and the combustion air.

M. Gas Supply:
1. Minimum/Maximum: 5” to 14” w.c.
2. Gas connection shall be a minimum of a 36” flexible stainless-steel connector furnished by manufacturer. A suitable shutoff valve shall be provided at each unit.
3. Gas supply piping must meet local requirements and be sized in accordance with BTU demand, available pressure, and the total equivalent length of pipe required (fittings included). Connection from supply line to burner units must be made in accordance with installation details.

N. Accessories:
1. Concentric vent kit for use with PVC intake and polypropylene exhaust vent pipes through wall or roof.
2. Acid neutralizing kit (as required, interior drains only).

O. Temperature Controls and Remote BAS Connectivity:
1. IR Unit control shall be provided via a programmable controller (24 volt) capable of providing night setback, holiday override, self-adapting optimized start and optimized shut down.
2. Temperature sensing to be supplied to the controller via a 24-volt (or line voltage) temperature and black bulb type radiant sensors.
3. Unoccupied Period Override: Two hours.
4. Connection to all units shall be with flexible conduit allowing for expansion and contraction. Do not mount a junction box on the appliance.
5. Wiring must conform to national electrical code, local ordinances, and in accordance with diagrams furnished. Electrical supply source shall be 120 volt/ 60hz of sufficient capacity to handle electrical requirements of the system. Electrical load per system shall be the sum of the individual burner units and, as applicable, the vacuum pump.
6. BAS Interface Requirements: Provide interface relay for scheduled operation, and interface relay to provide indication of fault at central workstation. Interface shall be BACnet compatible for central BAS workstation and include the following functions: Adjust set points; start-stop and status monitoring; room-air temperature monitoring; and occupied-unoccupied schedules.
7. Local BAS Interface Requirements: Provide Ethernet BAS connection capability at temperature sensor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Examine structures, substrates, areas and conditions, with Installer present, for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance of the Work. Examine roughing-in for fuel-gas piping to verify actual locations of piping connections before equipment installation. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54.

C. Suspended Units: Suspend from substrate using manufacturer's chain hanger kits and building attachments, or custom-fabricated brackets.
   1. Restrain the unit to resist seismic acceleration. Comply with requirements for seismic-restraint devices specified in Division 13 Section “Seismic Restraints.”
   2. Comply with requirements for hangers and supports specified in Division 23 Section “Hangers and Supports.”

D. Maintain manufacturers' recommended clearances for combustibles.

3.02 CONNECTIONS

A. Gas Piping: Comply with Division 22 Section “Natural-Gas Piping.” Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service. Connect gas piping to radiant heaters according to NFPA 54.

B. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.

C. Electrical Connections: Comply with applicable requirements in Division 23 Sections. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections. Perform the following tests and inspections:
   1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Verify bearing lubrication.
   3. Verify proper motor rotation.

B. Test Reports: Prepare written test and inspection reports to report the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.

D. Adjustments: Adjust initial-temperature set points. Adjust burner and other unit components for optimum heating performance and efficiency.

E. Training: Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain gas-fired, radiant heaters.

END OF SECTION

SECTION 23 74 13
PACKAGED ROOFTOP UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) used for single-duct, variable air volume, heating and cooling systems and single-duct heating and ventilating systems with the following components and accessories:
   1. Supply and return fans.
   2. Direct-expansion cooling.
   3. Refrigeration components.
   4. Natural-gas furnace.
   5. Economizer outdoor- and return-air damper section.
   6. Integral space temperature controls.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 23 Section “Motors” for motors used as an integral part of rooftop units specified in this section.
   2. Division 23 Section “Duct Accessories” for dampers used as an integral part of rooftop units specified in this Section.
   3. Division 23 Section “Air Filters” for filters used as an integral part of rooftop units specified in this Section.
   4. Division 23 Section “HVAC Instrumentation and Controls” for temperature controls, wiring, devices, components, and actuators for dampers furnished under this Section.
   5. Division 26 Section “Variable Frequency Drives” for material specification of variable frequency motor controllers furnished under this Section.

D. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units with gas-fired heating and direct expansion refrigeration.

E. HVU: Heating and ventilating unit: As used in this Section, this abbreviation means packaged, outdoor, heating and ventilating air-handling units with gas-fired heating.

1.03 PERFORMANCE REQUIREMENTS

A. Design RTU and HVU supports to comply with wind and seismic performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Wind-Restraint Performance:
   1. Basic Wind Speed: 30 mph.
   2. Building Classification Category: II.
   3. Minimum 10 lb/sq. ft (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Seismic Performance: RTU(s) and HVUs shall withstand the effects of earthquake motions determined according to Division 13 Section “Seismic Restraints.” The term “withstand” means

"the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.04 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU and HVU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Wiring Diagrams: Power, signal, and control wiring.

D. Calculations Submittal: For RTU and HVU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   3. Wind- and Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

E. LEED Submittal: Submit product data for LEED-NC v4 credit EAc6. Products must comply with LEED-NC v4 credit EAc6 as published by the US Green Building Council (USGBC). Any refrigerant which violates this credit is unacceptable on this project and will be rejected.

F. Manufacturer Wind Loading and Seismic Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Division 13 Section "Seismic Restraints."
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For RTU(s) and HVUs to include in emergency, operation, and maintenance manuals.

I. Warranty: Special warranty specified in this Section.

J. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section "Basic Mechanical Requirements."

1.05 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop air conditioners and are based on the specific system indicated. Refer to Division 23 Section "Basic Mechanical Requirements."

B. 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.

C. Fabricate and label refrigeration system to comply with ASHRAE 15-2019 Safety Standard for Refrigeration Systems.

D. Energy Compliance: No unit will be accepted which does not meet Table 6.8.1 values in ASHRAE Standard 90.1-2016 Energy Standard for Buildings Except Low-Rise Residential Buildings.

E. Comply with NFPA 54 for gas-fired furnace section.

F. AHRI Certification: Units shall be AHRI certified and listed.

G. AHRI Compliance for Units with Capacities 135,000 Btuh (39.6 kW) and More: Rate rooftop air-conditioner capacity according to AHRI 340/360 Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

H. Sound Power Level Ratings: Comply with AHRI 270 Sound Rating of Outdoor Unitary Equipment.

I. ASHRAE Compliance: Comply with ASHRAE 33 for methods of testing cooling and heating coils.

J. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

K. UL Compliance: Comply with UL 1995.

1.06 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

B. Coordinate size, location, and installation of roof curbs and equipment supports with roof installer.

1.07 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTU(s) and HVUs (where applicable) that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
   2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.
   3. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
   4. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.08 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 Belts: One set for each belt-driven fan, in addition to initial set.
   2. Filters: As specified in separate Division 23 Section "Air Filters," whose requirements apply to the work of this Section as if fully reproduced herein.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aaon, Inc.
   2. Addison Products Company.
   3. Carrier Global Corp.
   4. CES Group, Inc.

5. Daikin Applied.
6. Engineered Air.
7. Johnson Controls, Inc. (including York brand).
8. Trane Technologies plc.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section "Basic Mechanical Requirements." Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product's shop drawing submittal.

2.02 CASING

A. Materials: Formed and reinforced G-90 mill galvanized steel wall and top panels, fabricated to allow removal for access to internal parts and components without affecting the structural integrity of the unit, with joints between sections sealed.
   1. Outer Casing: Galvanized steel, minimum 18-gage.
   2. Inner Casing: Galvanized steel, minimum 24-gage solid inner walls. Fan sections of rooftop unit(s) shall be perforated.
   3. Floor Plate: Galvanized steel, minimum 18 gage solid.

B. Factory finish paint the entire outer casing. Finish shall pass a 672-hour salt spray test based on ASTM B117.

C. Base Rail: The entire unit shall be supported on a galvanized steel rail channel or rustproof-painted structural steel rail, designed with a continuous recessed curb mounting surface for field application of a gasket between curb and unit. Minimum rail height shall be 4-inches. Provide integral lifting lugs.

D. Roof: Pitched at ¼-inch per foot, minimum, with no low spots that could puddle water. Roof edges shall overhand the side panels by at least 2-inches. Roof and sidewall seams shall be continuously caulked and covered with seam caps.

E. Insulation: Polyurethane foam or glass-fiber insulation, complying with ASTM C1071 and NFPA 90A.
   1. Thermal Performance: k-value 0.26 BTU-in/(hr-sf-degF) at 75°F mean temperature.
   2. Thickness: 1 inch (25 mm), 1½-pound density.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C411.
   4. Location and Application: Encased between outside and inside casing.

F. Access Doors: Same materials and finishes as cabinet and complete with full-length stainless steel piano hinges, latches, handles, and gaskets.
   1. Access doors shall be sufficient in quantity and location to allow maintenance access to all fans, motors, dampers, coils, filters, heating elements, control boards, compressors, and refrigeration accessories.
   2. Latches: Quarter-turn lockable handles.
   3. Not Acceptable: Access panels which do not remain attached to the unit when opened.

G. Drain Pans: Readily cleanable, formed sections of stainless-steel sheet complying with ASHRAE Standard 62. Fabricate pans in sizes and shapes to collect condensate from cooling coils (including coil piping connections and return bends) when units are operating at maximum catalogued face velocity across cooling coil. Pans shall be sloped in two planes for complete drainage to a single outlet without standing water.
   1. Double-Wall Construction: Fill space between walls with 2-inch insulation and seal moisture tight.
   2. Drain Connection: Threaded nipple, same side of unit as coil connection side, unless noted otherwise; pre-piped to exterior of unit.

3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.
4. All portions of the drain pan, including intermediate pans and any hardware subject to contact with condensate, shall be constructed of Type 304 stainless steel.
5. Pan-Top Surface Coating: Elastomeric compound.
6. Fasteners: All fasteners exposed to weather shall be corrosion-resistant.
7. Minimum Depth: 2 inches (50 mm).

H. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in separate Division 13 Section “Seismic Restraints” when fan-mounted frame and RTU/HVU-mounted frame are anchored to building structure.

2.03 CENTRIFUGAL FANS

A. Fan-Section Construction: Fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan scroll, wheel, shaft, bearings, and motor on structural-steel frame, with frame mounted on base with vibration isolation. For belt drive, provide the following:
1. Install fans on housed spring vibration isolators, minimum 2-inch (50-mm) static deflection, with seismic snubbers. Vibration isolators shall be Mason Industries Model SLF or equal.
2. Install duct flexible connector at point of connection of fan discharge to the unit cabinet.

B. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.

C. Forward-Curved Fan Wheels: Black-enamel or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

D. Plenum “Plug” Fans: Steel construction with smooth-curved inlet flange, heavy backplate, and backward-curved or airfoil blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws. Fabricate without fan scroll and volute housing. Single-width, single-inlet style.

E. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange, heavy backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

F. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing; rated for duty at maximum fan speed.
1. Tapered roller bearings with double-locking collars meeting the above requirements will be acceptable.
2. Pre-lubricated and sealed-type ball bearings meeting the above requirements will also be acceptable.
3. Bearing Rating Life: ABMA 9, L10 of 40,000 hours (rooftop units only).
4. Bearing lubrication lines and grease fittings shall be extended to, and mounted adjacent to, unit access door(s) for easy accessibility.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor.
   1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   2. Belts: Oil resistant, non-sparking, and non-static; matched for multiple belt drives.
   3. Motor Mount: Adjustable for belt tensioning.

I. Fan Motors: Comply with requirements in separate Division 23 Section “Motors,” whose requirements apply to the work of this Section as if fully reproduced herein.

J. Power Cable Raceway: Any and all power cable installed inside the unit proper, such as (but not limited to) power cabling to the fan/motor assembly, shall be installed inside flexible or rigid conduit as further specified in Division 26 Section “Raceways.” Cabling installed inside a separate dedicated power or control enclosure need not be installed in raceway.

2.04 EVAPORATOR COIL

A. Coil Sections: Individual, insulated casing. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils.

B. Coil Casing: Same as cabinet construction. Isolate copper tubing from contact with steel casing members by using polymer strip or other non-conducting insulator material.

C. Circuit Arrangement: Circuit for interleaved capacity control. Number of rows shall be determined by manufacturer to meet scheduled performance requirements. Unless noted otherwise, do not exceed 6 rows.

D. Tubes: Copper complying with ASTM B75, ½-inch O.D. with 0.016-inch minimum wall; or 5/8-inch O.D. with 0.020-inch minimum wall.

E. Fins: Aluminum of minimum thickness 0.006-inch. Spacing shall not exceed 14 per inch.

F. Fin and Tube Joint: Mechanical bond created via thermal expansion.

G. Suction and Distributor: Seamless copper tube with brazed joints, with equalizing-type vertical distributor.

H. Condensate Drain Pan: As specified elsewhere within this Section.

I. Ratings: Design, test and rate according to ASHRAE 33 and AHRI 410.

2.05 AXIAL CONDENSER FANS

A. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.

B. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower. Fan assemblies shall be installed on unit housing with elastomeric mounts for vibration isolation.

C. Axial-Fan Wheels: Cast aluminum, with blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.
   1. Fan Hub and Blade-Bearing Assemblies: Cast aluminum, machined and fitted with threaded bearing wells to receive blade-bearing assemblies.
   2. Blades: Replaceable, cast aluminum; factory mounted and balanced to hub assembly.
   3. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan’s speed range.
   4. Pre-lubricated and sealed-type ball bearings meeting the above requirements will also be acceptable.
   5. Bearing Rating Life: ABMA 9, L_{10} of 40,000 hours.

D. Fan Motors: Comply with requirements in separate Division 23 Section “Motors,” whose requirements apply to the work of this Section as if fully reproduced herein. A separate motor is required for each condenser fan.

2.06 CONDENSER COIL

A. Condenser Coil: Same specifications as Evaporator Coil (above) except as follows:
   1. Include sub-cooling circuit and back-seating liquid-line service access valve.
   2. Condensate drain pan is not required for condenser coils.
   3. Microchannel Coils: Acceptable in lieu of copper-tube, aluminum-fin coil at manufacturer's option. Construct of all-aluminum in three components: flat microchannel tube, fins located between the microchannel tubes, and two refrigerant manifolds; all assembled using a nitrogen-charged brazing furnace process.

2.07 REFRIGERANT CIRCUIT COMPONENTS

A. Compressors: Positive displacement, scroll-type, direct drive with suction and discharge service valves, internal overcurrent and high-temperature protection, internal pressure relief, crankcase oil heater, and suction strainer. The compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading. Reciprocating compressors will not be accepted.
   1. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
   2. Capacity Control: On-off compressor cycling and variable-speed compressor control.
   3. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
   4. Compressor Motors: Hermetically sealed and cooled by refrigerant suction gas; high-torque, two-pole induction type with inherent thermal-overload protection on each phase.

B. Compressor Variable-Speed Controllers: Solid State; NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency; factory assembled and tested prior to shipment.
   1. Output: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout range.
   2. Pulse-width modulated (PWM) waveform with full-wave rectifier, DC bus choke, and DC bus capacitors.
   3. 1200-7200 rpm speed range.
   4. Protection and fault LED codes for diagnostics and troubleshooting.
   5. Stator heating capability.
   6. Finned (air-cooled) or flat plate (refrigerant cooled) heat sink.
   7. Dedicated compressor menu structure and parameters for setup.
   8. System integration module slots for additional I/O.
   9. Locked rotor detection.
   10. Phase protection and correction.
   11. Maximum operating current detection.
   12. Discharge line temperature protection.
   13. Anti-short cycling.

C. Compressors shall be installed on unit housing with elastomeric mounts for vibration isolation.

D. Refrigerant Compatibility: Seals, O-rings, motor windings, and internal parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

E. Refrigerant Circuit: At least two independent circuits are required. Each circuit shall include a thermal expansion valve, refrigerant charging connections, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line; all of which are specified elsewhere in this Section.

F. Refrigerant: Select among A1 refrigerants defined by ASHRAE Standard 34-2019.

G. Refrigeration Specialties:
   1. Expansion valve with replaceable thermostatic element.
   2. Refrigerant filter/dryer.
   3. Manual-reset high-pressure safety switch.
   4. Automatic-reset low-pressure safety switch.
   5. Minimum off-time relay.
   6. Automatic-reset compressor motor thermal overload.
   7. Brass service valves installed in compressor suction and liquid lines.

H. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch-(180-mm-) long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
   5. Maximum Operating Temperature: 250ºF (121ºC).

I. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Copper spring.
   5. Working Pressure Rating: 500 psig (3450 kPa).

J. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by UL or ETL.
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with ½-inch conduit adapter, and coil voltage coordinated with Condensing Unit.
   6. Working Pressure Rating: 400 psig (2760 kPa).
   7. Maximum Operating Temperature: 240ºF (116ºC).

K. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   2. Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Seat Disc: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Working Pressure Rating: 400 psig (2760 kPa).
   6. Maximum Operating Temperature: 240ºF (116ºC).

L. Thermostatic Expansion Valves: Comply with AHRI 750.
   1. Body, Bonnet, and Seal Cap: Forged brass or steel.
   2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Packing and Gaskets: Non-asbestos.
   4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   5. End Connections: Socket, flare, or threaded union.
   6. Working Pressure Rating: 450 psig (3100 kPa).

M. Strainers:
   1. Body: Welded steel with corrosion-resistant coating.

2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275ºF (135ºC).

N. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240ºF (116ºC).

O. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. End Connections: Socket.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 240ºF (116ºC).

2.08 AIR FILTRATION

A. As specified in separate Division 23 Section “Air Filters,” whose requirements apply to the work of this Section as if fully reproduced herein.

2.09 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54; designed and certified by and bearing label of CSA.

B. Burners: Stainless steel with a minimum thermal efficiency of 80 percent.
1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.

D. Venting: Gravity vented with vertical extension.

E. Safety Controls:
1. Gas Control Valve: Modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.10 DAMPERS

A. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously. Damper motors shall be modulating with adjustable minimum position. Include bird screen and hood.

2.11 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with door-interlock unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.12 CONTROLS

A. For individual unit control requirements for either the rooftop unit(s) or heating and ventilating units as well as BAS tie-ins, see the temperature controls drawings. Below are requirements mostly for the rooftop units.

B. Variable frequency drives for fans and other variable-speed devices packaged with the rooftop unit(s) shall be furnished, factory pre-wired, and factory-installed, all as the work of this Section. The specification of variable frequency drives is found in Division 26 Section “Variable Frequency Drives” whose requirements apply to the work of this Section as if fully reproduced herein.

C. Basic Unit Controls: Control-voltage transformer and wall-mounted thermostat or sensor with the following features:
   1. Heat-cool-off switch.
   2. Fan on-auto switch.
   3. Fan-speed switch.
   4. Automatic changeover.
   5. Adjustable deadband.
   6. Concealed set point.
   7. Concealed indication.
   8. Degree F indication.
   9. Unoccupied-period-override push button.
   10. Data entry and access port to input temperature setpoints, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.

D. Unit-Mounted Annunciator Panel for Each Unit:
   1. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
   2. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

E. Electronic controller shall have volatile-memory backup.

F. Safety Control Operation: Provide control interface to coordinate with operating sequence described in separate Division 26 Section “Fire Alarm Systems.”
   1. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
   2. Firestats: Stop fan and close outdoor-air damper if air greater than 130ºF enters unit. Provide additional contacts for alarm interface to fire alarm control panel.

G. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

H. Unoccupied Period:
   1. Heating Setback: 10ºF below occupied setpoint (adjustable).
   2. Cooling Setback: 6ºF above occupied setpoint (adjustable).
   3. Override Operation: Two hours.

I. Supply Fan Operation: Modulate supply fan speed as required to satisfy supply air discharge static pressure setpoint, within manufacturer’s high and low limits for safe operation. Static pressure sensor and static pressure control shall be factory-provided; static pressure setpoint shall be resettable via input from generic DDC system.
   1. Occupied Periods: Run fan continuously.
   2. Unoccupied Periods: Cycle fan to maintain setback temperature.

J. Refrigerant Circuit Operation: Cycle or stage compressors, to match compressor output to cooling load to maintain discharge temperature. Cycle condenser fans to maintain maximum hot-gas pressure.

K. Gas Furnace Operation: Modulate burner to maintain discharge temperature.

L. Economizer Outdoor-Air Damper Operation:
   1. Occupied Periods: Open to fixed minimum intake as scheduled, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II. Controller shall engage air-side economizer operation when outdoor air is less than 65ºF using a fixed dry-bulb changeover setpoint. Adjust modulating mixing dampers in cooler weather to blend return air and outdoor air for temperature control prior to use of mechanical heating or cooling. Start exhaust-air fan with end switch on outdoor-air damper.
   2. Unoccupied Periods: Same as occupied period except that minimum outdoor air damper position (when economizer is not applicable) is fully closed.
   3. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and ensure that minimum outdoor air is provided at all occupied conditions.

M. Economizer Fault-Detection and Diagnostics: Provide a Fault-Detection and Diagnostic (FDD) program certified with the State of California under Title 24 (regardless of the location of this project), which includes, as a minimum, the following features:
   1. Temperature Sensors: Outdoor air temperature, supply air temperature, return air temperature; all of which shall be accurate to within ±2°F over the range of 40°F to 80°F.
   2. Operating Modes Indication: Free cooling available; economizer enabled; compressor enabled; heating enabled; mixed air low limit cycle active.
   3. Fault Detection: Air temperature sensor failure/fault; not economizing when the unit should be economizing; economizing with the unit should not be economizing; damper(s) not modulating; excess outdoor air.

N. DDC: Stand-alone control module for link between unit controls and a generic DDC system. Control module shall be compatible with a generic temperature-control system meeting the requirements of ASHRAE Standard 135 BACnet protocol.
   1. Provide start and stop interface relay, and relay to notify generic DDC system alarm condition.
   2. Provide hardware interface or additional sensors for room temperature, discharge-air temperature, and mode (e.g., occupied, unoccupied, heating, cooling, setback, etc.)
   3. Accept input from generic DDC system to reset the RTU's static pressure setpoint based on status of VAV boxes connected thereto, as further described in Division 23 Section "HVAC Instrumentation and Controls."

2.13 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

C. Hail guards of galvanized steel, painted to match casing.

D. Rooftop Unit(s) Only): Powered return air centrifugal fan meeting the requirements of "Centrifugal Fan" article elsewhere in this Section.

2.14 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in separate Division 23 Section "Mechanical Vibration Isolation."

2.15 CAPACITIES AND CHARACTERISTICS

A. As scheduled on the Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTU(s) and HVUs.

B. Examine roughing-in for RTU(s) and HVUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTU(s) and HVUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTU(s) and HVUs on curbs and coordinate roof penetrations and flashing with existing roof construction. Secure RTU(s) and HVUs to upper curb rail, and secure curb base to roof framing with anchor bolts.

3.03 CONNECTIONS

A. Install cooling coil condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain. Field-furnish and install copper DWV piping and slope at 1% downward in the direction of flow.

B. Install piping adjacent to RTU(s) to allow service and maintenance.

C. Gas Piping: Comply with applicable requirements in Division 22 Section "Fuel Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

D. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination at top of roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to RTU(s) and HVUs with flexible duct connectors specified in Division 23 Section "Duct Accessories."
   4. Install return-air duct continuously through roof structure.

E. Connect wiring and ground equipment according to Division 26 Sections.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:
   1. After installing RTU(s) and HVUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

3.05 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service and economizer functional performance testing. Complete installation and startup checks according to manufacturer's written instructions and as follows.

B. Inspect for visible damage to unit casing, furnace combustion chamber, compressor, coils, and fans. Inspect internal insulation.

C. Verify that labels are clearly visible, that clearances have been provided for servicing, that controls are connected and operable, and that filters are installed. Verify lubrication on fan and motor bearings.

D. Clean condenser coil and furnace flue and inspect for construction debris.

E. Connect and purge gas line.

F. Remove packing from vibration isolators.

G. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

H. Adjust fan belts to proper alignment and tension.

I. Start unit according to manufacturer's written instructions. Start refrigeration system. Do not operate below recommended low-ambient temperature. Complete startup sheets and attach copy with Contractor's startup report. Operate unit for an initial period as recommended or required by manufacturer.

J. Inspect operation of relief dampers. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.

K. Inspect and record performance of interlocks and protective devices; verify sequences.

L. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
   1. Measure gas pressure on manifold.
   2. Inspect operation of power vents.
   3. Measure combustion-air temperature at inlet to combustion chamber.
   4. Measure flue-gas temperature at furnace discharge.
   5. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
   6. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

M. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown. Calibrate thermostats. Adjust and inspect high-temperature limits.

N. Simulate maximum cooling demand and record the compressor refrigerant suction and hot-gas pressures. Inspect for short-circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

O. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
   1. High-temperature limit on gas-fired heat exchanger.
   2. Low-temperature safety operation.
   3. Filter high-pressure differential alarm.
   4. Economizer to minimum outdoor-air changeover.
   5. Return air fan operation.

6. Smoke and fire stat alarms.

3.06 CLEANING AND ADJUSTING

A. After completing system installation and testing, adjusting, and balancing RTU/H&V and air-distribution systems, clean filter housings and install new filters.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTU(s) and HVUs. Refer to Division 01.

B. Perform field functional testing of the economizer and complete Form NRCA-MCH-05-A NA7.5.4 Air Economizer Controls Acceptance. Submit the Certificate of Acceptance.

END OF SECTION

SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes split-system air-conditioning units 5-tons and smaller, consisting of separate evaporator-fan and compressor-condenser components.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Wiring Diagrams: For power, signal, and control wiring.

C. LEED Submittal: Submit product data for LEED-NC v4 credit EAc6. Products must comply with LEED-NC v4 credit EAc6 as published by the US Green Building Council (USGBC). Any refrigerant which violates this credit is unacceptable on this project and will be rejected.

D. Field quality-control reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

F. Warranty: Sample of special warranty.

G. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

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

B. AHRI Compliance: All split-system units shall be rated in accordance with Air-conditioning Heating Refrigeration Institute’s (AHRI) Standard 210 and bear the AHRI Certification label.

C. Fabricate and label refrigeration system to comply with ASHRAE 15-2019 *Safety Standard for Refrigeration Systems.*

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1-2016, Section 4 - “Outdoor Air Quality,” Section 5 - “Systems and Equipment,” Section 6 - “Procedures,” and Section 7 - “Construction and System Start-Up.”

E. Energy Compliance: No condensing unit and/or split-system will be accepted which does not meet Table 6.8.1 values in ASHRAE Standard 90.1-2016 *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

1.05 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Sections.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.06 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-systems that fail in materials or workmanship within five (5) years from date of Substantial Completion. Failures include, but are not limited to, compressor failure and/or refrigerant coil leak.

1.07 EXTRA MATERIALS

A. Furnish one additional complete set of filters for each unit that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Daikin Applied Americas Inc.
   2. Fujitsu General America, Inc.
   3. Lennox International Inc.
   4. LG Products.
   5. Mitsubishi Electric.
   6. Panasonic Corporation.
   7. Samsung HRP.
   8. Trane Technologies plc.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section "Basic Mechanical Requirements." Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product's shop drawing submittal.

2.02 INDOOR UNITS, 5 TONS (18 KW) OR LESS

A. Ductless Console Cabinet: Galvanized steel frame with enameled steel or extruded thermoplastic panels; with removable panels on front and ends in color selected by Architect. Insulate interior with faced glass-fiber duct liner insulation. Include integral, user-adjustable discharge grille.

B. Evaporator Coil: Seamless copper tube, with mechanically bonded aluminum fins and electronic expansion valve. Comply with AHRI 210/240.

C. Fan: Direct-drive, centrifugal. The fan shall be statically and dynamically balanced, with permanently lubricated bearings.

D. Fan Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23 Section "Motors."
   1. Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
   2. Wiring Terminations: Connect motor to chassis wiring with plug connection.
   3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2016.

F. Condensate Drain Pans: Single-wall, stainless-steel sheet, fabricated with not less than one-percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends), and to direct water toward drain connection. Drain connection shall be located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

G. Disposable Panel Filters: Comply with NFPA 90A; MERV-6 according to ASHRAE 52.2. Media shall be interlaced glass fibers sprayed with nonflammable adhesive.

2.03 OUTDOOR UNITS, 6 TONS (18 KW) OR LESS

A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Scroll Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor. Reciprocating compressors will not be accepted.

C. Refrigerant Charge: R-407C or R-410A.

D. Condenser Coil: Seamless copper tube, with mechanically bonded aluminum fins and liquid subcooler; or microchannel coil of all-aluminum assembled via brazing. Comply with AHRI 210/240. The coil shall be protected with an integral metal guard.

E. Refrigerant Circuit: Each circuit shall include a thermal expansion valve, refrigerant charging connections, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line; all of which are specified elsewhere in this Section.

F. Condenser Fan: Aluminum-propeller type, directly connected to motor. The fan shall be provided with a safety guard to prevent human contact with moving parts

G. Fan Motor: Permanently lubricated, with integral thermal-overload protection.

H. Low Ambient Kit: Permit operation down to 0ºF (2 C).

I. Mounting Base: Polyethylene.

J. Enclosure: Furnish and ship loose for field installation, manufacturer's heavy-gage wire-mesh screen or louvered skirt to protect machine from entry by unauthorized personnel. Such screen or skirt shall mount directly to the machine and completely enclose or protect all exposed parts, including but not limited to fans, compressors, piping, controls, and accessories.

2.04 VALVES AND SPECIALTIES

A. General: All of the following devices are required as either factory-installed and pre-piped; or field-provided if not factory-provided. All of the following devices shall be Working Pressure Rated for 500 psig (3450 kPa) at an Operating Temperature of 240ºF (116ºC).

B. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   3. Seat: PTFE.
   4. End Connections: Copper spring.

C. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.

3. Offset Performance: Capable of minimum ¾-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

D. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by UL or ETL.
1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: PTFE.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with ½-inch conduit adapter, and coil voltage coordinated with Condensing Unit.

E. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: PTFE.
4. End Connections: Threaded.

F. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. End Connections: Socket, flare, or threaded union.

G. Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.

H. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.

I. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. End Connections: Socket.

2.05 ACCESSORIES

A. Thermostat: Low voltage with sub-base to control compressor and evaporator fan.

B. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

E. Condensate Pump: Unit manufacturer's pump-motor assembly with integral float switch and condensate reservoir; powered from indoor unit without the need for a separate circuit. Subject to compliance with requirements, example of suitable device is Model VCMA20 by Little Giant. Pump shall have the following characteristics:
   1. Vertical-type, fully automatic, ½-gallon capacity, and stainless-steel motor shaft.
   2. Rust-proof, high-impact ABS volute, tank and motor cover; 3 drain holes, and removable 3/8-inch OD barbed check valve.
   3. Pump shall be equipped with a safety switch that can shut down the unit in the event of tank overflow.
   4. The motor shall be thermally protected and shall be UL and CSA listed.

2.06 CAPACITIES AND CHARACTERISTICS

A. Capacities and characteristics are scheduled on the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb, and in accordance with manufacturer's written installation instructions. Set equipment supports so top surface of equipment is level.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base that is 4 inches (100 mm) larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

E. Install seismic restraints as further specified in Division 13 Section "Seismic Restraints."

F. Install components on resilient mountings as further specified in Division 23 Section "Mechanical Vibration Isolation."

G. See Division 23 Section "Basic Mechanical Materials and Methods" for additional anchorage and concrete base requirements.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit. If manufacturer's pre-charged refrigerant tubing is of insufficient length, field-provide copper ACR refrigeration tubing with brazed joints.
   2. Condensate Drain: Plastic drainpipe is not acceptable. Field-furnish and install copper DWV piping.
   3. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

B. Insulate all field piping as further specified in Division 23 Section "Mechanical Insulation."

C. Connect wiring and ground equipment in accordance with Division 26 Sections.

D. Furnish and install signal and control wiring, including but not limited to interconnection between condensing unit associated evaporator unit, as the work of this Section but meeting all applicable requirements of Division 23 Section “HVAC Instrumentation and Controls.”

3.03 FIELD PIPING

A. Copper Tube: ASTM B280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Suction Lines, Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

G. Condensate Drain: DWV Copper Tubing, ASTM B306.

H. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

I. Install refrigerant piping according to ASHRAE 15.

J. Install piping adjacent to machines to allow service and maintenance.

K. Install piping free of sags and bends.

L. Install fittings for changes in direction and branch connections.

M. Select system components with pressure rating equal to or greater than system operating pressure.

N. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

O. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

P. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Liquid lines may be installed level.

Q. When soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

T. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

U. Soldered Joints: Construct joints according to ASTM B 828 or CDA’s *Copper Tube Handbook*.

V. Hanger, support, and anchor products are specified in Division 23 Section “Hangers and Supports.”

3.04 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line.

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Required Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

D. Prepare and submit test and inspection reports.

3.06 CLOSEOUT

A. Engage a factory-authorized service representative to perform startup service, and to train Owner's maintenance personnel to adjust, operate, and maintain units. Complete installation and startup checks according to manufacturer's written instructions.

END OF SECTION

SECTION 23 81 28
VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes variable refrigerant flow systems consisting of multiple evaporator-fan indoor units coupled to one or more outdoor compressor-condenser components, including interconnecting refrigerant piping and controls; designed to allow heating in one zone and cooling in another zone simultaneously.

1.02 RELATED DOCUMENTS

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

B. Section 20 08 00 “Seismic Protection,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Wiring Diagrams: For power, signal, and control wiring.

C. LEED Submittal: Submit product data for LEED-NC v4 credit EAc6. Products must comply with LEED-NC v4 credit EAc6 as published by the US Green Building Council (USGBC). Any refrigerant which violates this credit is unacceptable on this project and will be rejected.

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

E. Field quality-control reports.

F. Operation and Maintenance Data: For variable refrigerant flow systems to include in emergency, operation, and maintenance manuals.

G. Warranty: Sample of special warranty.

H. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

1.04 QUALITY ASSURANCE

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

B. AHRI Compliance: All variable refrigerant flow systems shall be rated in accordance with Air-conditioning Heating Refrigeration Institute’s (AHRI) Standard 1230 and bear the AHRI Certification label.

C. ASHRAE 15 Compliance: Fabricate and label refrigeration system to comply with ASHRAE 15-2019 *Safety Standard for Refrigeration Systems*.

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1-2019, Section 4 - “Outdoor Air Quality,” Section 5 - “Systems and Equipment,” Section 6 - “Procedures,” and Section 7 - “Construction and System Start-Up.”

E. Energy Compliance: No variable refrigerant flow system component will be accepted which does not meet Table C-1 values in ASHRAE Standard 189.1-2014 *The Standard for the Design of High-Performance, Green Buildings except Low-Rise Residential Buildings*.

1.05 DELEGATED DESIGN

A. Delegated-Design: Due to the custom nature of variable refrigerant flow systems, the vendor, manufacturer, or proposer shall provide and submit a complete system design, including design of all field refrigerant pipe sizing and layout to interconnect all system components – not just a component product submittal. Design shall be customized to the specific building of this project.

B. Delegated-Design Submittal: For variable refrigerant flow 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.

C. See Division 23 Section “Basic Mechanical Requirements” for submittal of product manufacturer other than the basis-of-design.

1.06 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Sections.

1.07 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of variable refrigerant flow system components that fail in materials or workmanship within five (5) years from date of Substantial Completion. Failures include, but are not limited to, compressor failure and/or refrigerant coil leak.

1.08 EXTRA MATERIALS

A. Furnish one additional complete set of filters for each evaporator unit that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Daikin Applied.
   2. Fujitsu General America, Inc.
   3. Johnson Controls, Inc.
   4. LG Electronics USA, Inc.
   5. Mitsubishi Electric & Electronics USA, Inc.
   6. Toshiba Carrier UK Ltd.
   7. Trane Technologies plc.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 INDOOR EVAPORATOR UNITS

A. Ductless Console Cabinet: Galvanized steel frame with enameled steel or extruded thermoplastic panels; with removable panels on front and ends in color selected by Architect. Insulate interior with faced glass-fiber duct liner insulation. Include integral, user-adjustable discharge grille.

B. Evaporator Coil: Seamless copper tube, with mechanically bonded aluminum fins and electronic expansion valve. Comply with AHRI 210/240.

C. Fan: Direct-drive, centrifugal. The fan shall be statically and dynamically balanced, with permanently lubricated bearings.

D. Fan Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23 Section “Motors.”
   1. Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
   2. Wiring Terminations: Connect motor to chassis wiring with plug connection.
   3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

E. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat on a zone-by-zone basis; to permit heating in one zone and cooling in another zone simultaneously.

F. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2019.

G. Condensate Drain Pans: Single-wall, stainless-steel sheet, fabricated with not less than one-percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends), and to direct water toward drain connection. Drain connection shall be located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

H. Disposable Panel Filters: Comply with NFPA 90A; MERV-6 according to ASHRAE 52.2. Media shall be interlaced glass fibers sprayed with nonflammable adhesive.

2.03 OUTDOOR CONDENSING UNITS

A. Description: Factory assembled and tested, air-cooled; consisting of casing, scroll compressors, condenser coils, condenser fans and motors, and unit controls.

B. Compressors: Positive displacement, variable-speed, hermetic scroll-type, with suction and discharge service valves, internal overcurrent and high-temperature protection, internal pressure relief, crankcase oil heater, and suction strainer. The compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
   1. Compressor Casing: Hermetically sealed casing.
   2. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
   3. Capacity Control: Variable-speed compressors via inverter or reluctance DC motor.
   4. Vibration Isolation: Resiliently-mount individual compressors to unit frame.
   5. Compressor Motors: Hermetically sealed and cooled by refrigerant suction gas. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
   6. Reciprocating compressors will not be accepted.

C. Refrigerant Compatibility: Seals, O-rings, motor windings, and internal parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

D. Refrigerant Circuit: Each circuit shall include a thermal expansion valve, refrigerant charging connections, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line; all of which are specified elsewhere in this Section.

E. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including sub-cooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
   1. Coil Casing: Same as cabinet construction. Isolate copper tubing from contact with steel casing members by using polymer strip or other non-conducting insulator material.
   2. Circuit Arrangement: Circuit for interleaved capacity control.
   3. Piping Connections: Brazed fittings.
   4. Tubes: Copper complying with ASTM B75, ½-inch O.D. with 0.016-inch minimum wall; or 5/8-inch O.D. with 0.020-inch minimum wall.
   5. Fins: Aluminum of minimum thickness 0.006-inch. Spacing shall not exceed 12 per inch.
   6. Fin and Tube Joint: Mechanical bond created via thermal expansion.

7. Suction and Distributor: Seamless copper tube with brazed joints, with equalizing-type vertical distributor.
8. Ratings: Design, test and rate according to ASHRAE 33 and AHRI 410.
9. Microchannel Coils: Acceptable in lieu of copper-tube, aluminum-fin coil at manufacturer's option. Construct of all-aluminum in three components: flat microchannel tube, fins located between the microchannel tubes, and two refrigerant manifolds; all assembled using a nitrogen-charged brazing furnace process.

F. Condenser Fans: Propeller-type vertical discharge; direct-drive. Cast aluminum, with blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key. Include the following:
1. Permanently lubricated ball-bearing motors.
2. Separate motor for each fan.
3. Dynamically and statically balanced fan assemblies.
4. Fan Hub and Blade-Bearing Assemblies: Cast aluminum, machined and fitted with threaded bearing wells to receive blade-bearing assemblies.
5. Blades: Replaceable, cast aluminum; factory mounted and balanced to hub assembly.
6. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
7. Pre-lubricated and sealed-type ball bearings meeting the above requirements will also be acceptable.
8. Bearing Rating Life: ABMA 9, L_{10} of 40,000 hours.

G. Operating and safety controls shall include the following:
1. Manual-reset, high-pressure cutout switches.
2. Automatic-reset, low-pressure cutout switches.
3. Low oil pressure cutout switch.
4. Compressor-winding thermostat cutout switch.
5. Three-leg, compressor-overload protection.
6. Control transformer.
7. Magnetic contactors for compressor and condenser fan motors.
8. Timer to prevent excessive compressor cycling.

H. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features shall include the following:
1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
3. Gasketed control panel door.
4. Non-fused disconnect switch, factory mounted and wired, for single external electrical power connection.
5. Condenser coil hail guard to protect coil from physical damage.
6. Enclosure: Furnish and ship loose for field installation, manufacturer's heavy-gage wire-mesh screen or louvered skirt to protect machine from entry by unauthorized personnel. Such screen or skirt shall mount directly to the machine and completely enclose or protect all exposed parts, including but not limited to fans, compressors, piping, controls, and accessories.

I. Motors: General requirements for motors are specified in Division 23 Section "Motors." Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0. Controllers, wiring, and other electrical devices and connections are specified in Division 26 Sections.

2.04 ACCESSORIES

A. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
   1. Compressor time delay.
   2. 24-hour time control of system stop and start.
   3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   4. Fan-speed selection including auto setting.

B. Condensate Pump: Unit manufacturer's pump-motor assembly with integral float switch and condensate reservoir; powered from indoor unit without the need for a separate circuit. Subject to compliance with requirements, example of suitable device is Model VCMA20 by Little Giant. Pump shall have the following characteristics:
   1. Vertical-type, fully automatic, ½-gallon capacity, and stainless steel motor shaft.
   2. Rust-proof, high-impact ABS volute, tank and motor cover; 3 drain holes, and removable 3/8-inch OD barbed check valve.
   3. Pump shall be equipped with a safety switch that can shut down the unit in the event of tank overflow.
   4. The motor shall be thermally protected and shall be UL and CSA listed.

2.05 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. DuPont Company; Fluorochemicals Div.
   2. Honeywell, Inc.; Genetron Refrigerants.

B. Select one of the following refrigerants at condensing unit manufacturer's option:
   1. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
   2. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

2.06 VALVES AND SPECIALTIES

A. General: All of the following devices are required as either factory-installed and pre-piped; or field-provided if not factory-provided. All of the following devices shall be Working Pressure Rated for 500 psig (3450 kPa) at an Operating Temperature of 240ºF (116ºC).

B. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   3. Seat: PTFE.
   4. End Connections: Copper spring.

C. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum ¾-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

D. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by UL or ETL.
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: PTFE.
   4. End Connections: Threaded.
   5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with ½-inch conduit adapter, and coil voltage coordinated with Condensing Unit.

E. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   2. Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Seat Disc: PTFE.
   4. End Connections: Threaded.

F. Thermostatic Expansion Valves: Comply with AHRI 750.
   1. Body, Bonnet, and Seal Cap: Forged brass or steel.
   2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Packing and Gaskets: Non-asbestos.
   4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   5. End Connections: Socket, flare, or threaded union.

G. Strainers:
   1. Body: Welded steel with corrosion-resistant coating.
   2. Screen: 100-mesh stainless steel.
   3. End Connections: Socket or flare.

H. Moisture/Liquid Indicators:
   1. Body: Forged brass.
   2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
   3. Indicator: Color coded to show moisture content in ppm.
   4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
   5. End Connections: Socket or flare.

I. Replaceable-Core Filter Dryers: Comply with AHRI 730.
   1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina.
   4. End Connections: Socket.

2.07 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate condensing units according to AHRI 210/240 and/or AHRI 340/360 as applicable to unit capacity.

B. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Testing Requirements: Factory test sound-power-level ratings according to AHRI 270.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb, and in accordance with manufacturer’s written installation instructions. Set equipment supports so top surface of equipment is level.

B. Install evaporator-fan components using manufacturer’s standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base that is 4 inches (100 mm) larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Division 03 Sections. Coordinate anchor installation with concrete base.

D. Install seismic restraints as further specified in Division 20 Section “Seismic Protection.”

E. Install components on resilient mountings as further specified in Division 23 Section “Mechanical Vibration Isolation.”

F. See Division 23 Section “Basic Mechanical Materials and Methods” for additional anchorage and base requirements.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

B. Condensate Drain: Plastic drain hose is not acceptable. Field-furnish and install copper DWV piping as further specified in Division 23 Section “Hydronic Piping”

C. Insulate all field piping and ductwork as further specified in Division 23 Section “Mechanical Insulation.”

D. Connect wiring and ground equipment in accordance with Division 26 Sections.

3.03 FIELD PIPING

A. Copper Tube: ASTM B280, Type ACR, drawn-temper.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8.

E. Suction Lines, Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

G. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Install refrigerant piping according to ASHRAE 15. Observe that ASHRAE 15 does not permit routing of refrigerant piping in any elevator, dumbwaiter, an enclosed public stairway, stair landing, or means of egress.

J. Install piping adjacent to machines to allow service and maintenance. Install piping free of sags and bends. Install fittings for changes in direction and branch connections. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

K. Slope refrigerant piping according to service. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor. Install horizontal suction lines with a uniform slope downward to compressor. Install traps and double risers to entrain oil in vertical runs. Liquid lines may be installed level.

L. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

N. Identify refrigerant piping and valves according to Division 23 Section “Basic Mechanical Materials and Methods.”

O. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

P. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube." Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

Q. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports."

3.04 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
   4. Charge system with a new filter-dryer core in charging line.

3.05 ADJUSTING

A. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

B. Adjust set-point temperature of air-conditioning controllers to the system design temperature.

C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   1. Verify that compressor oil level is correct.
   2. Open compressor suction and discharge valves.
   3. Open refrigerant valves except bypass valves that are used for other purposes.
   4. Check open compressor-motor alignment and verify lubrication for motors and bearings.

D. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Perform electrical test and visual and mechanical inspection.
   2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   5. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Remove and replace malfunctioning condensing units and retest as specified above.

E. Field Piping Pressure Test: Coordinate with specific refrigerant to be provided; then comply with the following.
   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated below.
4. Fill system with nitrogen to the required test pressure. System shall maintain test pressure at the manifold gage throughout duration of test.
5. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
6. Line Test Pressure for Refrigerant R-407C: 230 psig (1586 kPa) for suction lines, and 380 psig (2620 kPa) for hot-gas and liquid lines.
7. Line Test Pressure for Refrigerant R-410A: 300 psig (2068 kPa) for suction lines, and 535 psig (3689 kPa) for hot-gas and liquid lines.

3.07 STARTUP SERVICE

A. Manufacturer's Field Service: Engage a factory-authorized service representative to assist in startup; and to train Owner's maintenance personnel to adjust, operate, and maintain VRF units. Refer to Division 01.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Inspect for physical damage to unit casing.
   2. Verify that access doors move freely and are weather-tight.
   3. Clean units and inspect for construction debris.
   4. Verify that all bolts and screws are tight.
   5. Adjust vibration isolation and flexible connections.
   6. Verify that controls are connected and operational.

C. Lubricate bearings on fans. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.

D. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.

E. Measure and record airflow over coils. Verify proper operation of condenser capacity control device. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

END OF SECTION

SECTION 23 82 39
IN-ROOM TERMINAL EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes the following types of in-room terminal equipment:
   1. Cabinet unit heaters with centrifugal fans and electric-resistance heating coils.
   2. Propeller unit heaters with electric-resistance heating coils.

1.02 RELATED DOCUMENTS

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

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

1.03 DEFINITIONS

A. BAS: Building automation system.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.04 SUBMITTALS

A. Product Data: For each type of product, include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals: Product Data for LEED-NC v4 prerequisite EQp1: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 – “Systems and Equipment.”

C. Shop Drawings:
   1. Include plans, elevations, sections, and details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include location and size of each field connection.
   4. Include details of anchorages and attachments to structure and to supported equipment.
   5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
   6. Indicate location and arrangement of integral controls.

D. Wiring Diagrams: Power, signal, and control wiring.

E. Seismic Qualification Certificates: Submit certification that in-room terminal units, accessories, and components will withstand seismic forces defined in Division 13 Section “Seismic Restraints.” Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a

formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

G. Field quality-control reports.

H. Operation and Maintenance Data: For in-room terminal units to include in emergency, operation, and maintenance manuals.

1.05 EXTRA MATERIALS

A. Furnish extra filters described in Division 23 Section “Air Filters” that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.06 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - “Systems and Equipment” and Section 7 - “Construction and Startup.”

B. Airstream Surfaces: All surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - “Heating, Ventilating, and Air-Conditioning.”

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

E. Seismic Performance: In-room terminal units shall withstand the effects of earthquake motions determined according to Division 13 Section “Seismic Restraints.”
   1. The term “withstand” means “the unit will remain in place without separation of any parts when subjected to the seismic forces specified.”

PART 2 - PRODUCTS

2.01 IN-ROOM TERMINAL EQUIPMENT, GENERAL (ALL UNITS)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Electric In-Room Terminal Heating Equipment:
      a. Chromalox; div. of Spirax-Sarco Engineering plc.
      b. Indeeco; div. of ASPEQ Heating Group.
      c. Markel Products Company; TPI Corporation.
      d. Marley Engineered Products; Qmark and Berko brands.
      e. Trane Technologies plc.

B. Capacities and Characteristics: As Scheduled on the Drawings.

C. Provide unit heaters with factory disconnect switch.

D. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

2.02 CABINET UNIT HEATERS

A. Description: Factory-assembled and -tested unit complying with AHRI 440.

B. Comply with UL 2021.

C. Coil-Section Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have aluminum-foil facing to prevent erosion of glass fibers.
   1. Thickness: Minimum ½-inch (13 mm).
   2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75°F (0.037 W/m x K at 24°C) mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.

D. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
   1. Horizontal Concealed Unit, Exposed Bottom Panels: Minimum 0.0528-inch- (1.35-mm-) thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   2. Recessed Flanges: Steel, finished to match cabinet.
   3. Control Access Door: Key operated.

E. Filters: Pleated, one-inch thickness, MERV-8 according to ASHRAE 52.2, and as further specified in Division 23 Section "Air Filters" whose requirements apply to the work of this section as if fully reproduced herein.

F. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

G. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board; and as further specified in Division 23 Section "Motors" whose requirements apply to the work of this section as if fully reproduced herein.
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

H. Basic Unit Controls:
   1. Control voltage transformer.
   2. Unit-mounted thermostat with the following features:
      a. Heat-off switch.
      b. Fan on-auto switch.
      c. Manual fan-speed switch.
      d. Adjustable deadband.
      e. Concealed set point.
      f. Concealed indication.

I. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.03 PROPELLER UNIT HEATERS

A. Description: Assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

B. Comply with UL 2021.

C. Comply with UL 823.

D. Housing Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

E. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

F. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550°F (288°C) at any point during normal operation.
   1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
   2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

G. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

H. Motor: Permanently lubricated, single speed and as further specified in Division 23 Section "Motors" whose requirements apply to the work of this section as if fully reproduced herein.

I. Explosion-Proof: Provide explosion-proof construction where indicated on the drawings.

J. Control Devices:
   1. Unit-mounted thermostat.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas to receive in-room terminal equipment for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

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

3.02 INSTALLATION

A. Install in-room terminal equipment to comply with NFPA 90A.

B. Suspend in-room terminal units from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in Division 23 Section "Mechanical Vibration Isolation" and Division 13 Section "Seismic Restraints."

C. Install new filters in each cabinet unit heater within two weeks of Substantial Completion.

3.03 CONNECTIONS

A. Comply with safety requirements in UL 1995.

B. Connect wiring and ground equipment according to Division 26 Sections.

3.04 FIELD QUALITY CONTROL

A. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

B. Operate electric heating elements through each stage to verify proper operation and electrical connections.

C. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment. Units will be considered defective if they do not pass tests and inspections. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. This Section specifies the basic requirements for electrical installations and includes requirements common to all sections of Division 26. It expands and supplements the requirements specified in sections of Division 00. This section is also applicable to Division 27 “Communications” and Division 28 “Electronic Safety and Security”.

B. Drawings and general provisions of the Contract, including general and supplementary conditions and specification sections Divisions 00 through 01, apply to this Section.

C. Codes and Standards: All equipment, material and installations shall comply with applicable codes, standards, and installation practices. Comply with the requirements of the applicable local building codes, the applicable NEC, all local rules and regulations including those of the fire authorities. Comply with all applicable NFPA standards. All material and equipment shall be listed by the Underwriters Laboratories (UL) standard that is applicable for the specific purpose of the material and equipment. The National Electrical Code, National Electrical Manufacturer’s Association (NEMA) Standards, and applicable ANSI and IEEE standards shall apply to the pertinent materials, equipment, and installation practices. Testing shall be in accordance with the applicable International Electrical Testing Association (NETA) standards.

1. These specifications include references to the 2020 edition of the NFPA 70 "National Electrical Code." Where a different edition of the NEC has been adopted by the local Authority Having Jurisdiction, the references associated with that edition of the Code shall be applicable.

1.02 SUMMARY OF WORK

A. The word “furnish” means supply for use, the word “install” means install in its proper location and connect up complete and ready for operation, and the word “provide” means to furnish and install.

B. Provide all new materials as indicated on the drawings and specifications and all items required to make the electrical system complete and in working order.

C. System descriptions included in scope of work are as follows:

1. Electrical power systems, including luminaires, distribution equipment, motors, wiring devices, etc.
2. Electrical power distribution service from the Utility Company including metering.
3. Grounding system.
4. Fire alarm system.
5. Power source for temperature control system.
6. Lightning protection system.
7. Wiring of equipment furnished by the Owner or other Divisions.
8. Low voltage systems as described in Divisions 27 and 28.
9. Low voltage systems rough-in, as indicated on drawings, for installation of low voltage equipment by others.

D. Work not included:

1. Temperature control wiring for plumbing and HVAC equipment (unless otherwise indicated) shall be by other Divisions.

1.03 ELECTRICAL COORDINATION DRAWINGS

A. Prepare a set of coordination drawings showing major elements, components, and systems of electrical equipment and materials in relationship with other building components. Prepare

drawings to an accurate scale of 1/4 inch = 1 foot-0 inches or larger. Indicate the locations of all equipment and materials, including clearances for servicing and maintaining equipment.

B. Prepare floor plans, reflected ceiling plans, elevations, sections and details to conclusively coordinate and integrate all installations. Show National Electrical Code-required clearances, maintenance access, and equipment removal clearances. Indicate locations where space is limited and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
   1. Equipment room layouts.
   2. Specific equipment installations, including, but not limited to the following:
      a. Panelboards
      b. Switchboards
      c. Transformers
   3. Wiring diagrams: Indicating field-installed electrical power and control wiring and cabling layouts, overcurrent protective devices, equipment and equipment connections.
   4. Work in pipe spaces, chases, trenches and tunnels.
   5. Exterior wall penetrations.
   6. Ceiling plenums which contain piping, ductwork, or equipment in congested arrangements.
   7. Exterior underground lines.

C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls and other structural components as they are constructed.

D. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.04 QUALITY ASSURANCE

A. Responsibility Prior to Submitting Pricing or Bid Data:
   1. Thoroughly review the contract documents and specifications and visit the site prior to issuing bid. Resolve all reported deficiencies with the Engineer prior to awarding any subcontracts, ordering material, or starting any work.

B. Qualifications:
   1. Only products of specified manufacturers, or approved equals as determined by the Engineer, are acceptable.
   2. Employ only workmen who are skilled in their trades.

C. Compliance with Codes, Laws, and Ordinances:
   1. Conform to all requirements of the state, city and local codes, laws and ordinances and other regulations having jurisdiction over this installation.
   2. Conform to all applicable Unified Facilities Criteria (UFCs) and National Guard standards.
   3. If there are any discrepancies between the codes and regulations and these specifications, the Engineer shall determine the method or equipment to be used.
   4. Inform the Engineer in writing, requesting a clarification at the time of the bidding, if any parts of the drawings or specifications are found not to comply with the codes or regulations. Submit a separate price to make the system comply if there is insufficient time for this procedure.
   5. Inform the Engineer in writing requesting a clarification if there is any discrepancy between a manufacturer’s recommendation and these specifications.
   6. Follow the current issue of NFPA 70 “National Electrical Code” if there are no local codes having jurisdiction.

D. Utility Company (Ameren) Requirements:

1. Secure all applicable requirements from Ameren, including Ameren Service Manual.
2. Comply with all Ameren requirements for service equipment, installation and metering.
3. Make application for and pay for new electrical service equipment and installation. Coordinate schedule and requirements with the Owner and Ameren.

E. Examination of Drawings:
1. The drawings for the indicated work are diagrammatic, intended to convey the scope of the electrical work and to indicate the general arrangements and locations of equipment, wiring devices, etc., and the approximate sizes of equipment. Field verification of dimensions on plans is required. The actual conditions, including heights, lengths and orientation shall be the basis of the work.
2. The architectural, structural, mechanical and electrical drawings and specifications shall be considered as mutually explanatory and complementary. Any electrical work called for by one and not by the other shall be performed as though required by all. All sections and subsections of the Electrical work shall be governed by and subject to the general and supplementary conditions. Report any discrepancies in or between the drawings and specifications, or between the drawings and actual field conditions to the Engineer in sufficient time to issue an addendum for clarification.
3. Determine the exact locations for equipment and rough-ins, and the exact routing of raceways.
4. Do not scale drawings to determine equipment and system locations.
5. Not all required components are shown on the documents, including junction boxes, pull boxes, conduit fittings, etc. Provide all components required for proper installation of the work.
6. Any item either shown on the drawings or called for in the specifications shall be included in this contract.
7. Determine quantities and quality of material and equipment required from the documents. Provide the more expensive or higher quality amount where discrepancies arise among drawings, schedules or specifications.

F. Electronic Media and Files:
1. Electronic media files of the contract drawings in AutoCAD or PDF format and copies of the specifications in PDF format may be requested.
2. Complete and return a signed “Electronic File Transmittal” form provided by Introba upon request for electronic media.
3. Obtain approval from the appropriate Design Professional for use of their part of the documents if the information requested includes information prepared by other than Introba.
4. The electronic contract documents may be used for preparation of shop drawings and record drawings only. The information may not be used in whole or in part for any other project.
5. The drawings prepared by Introba for bidding purposes may not be used directly for raceway layout drawings or coordination drawings.
6. The use of these documents does not allow relief from the responsibility for coordination of work with other trades and verification of space available for the installation.
7. The information is provided to expedite the project with no guarantee by Introba as to the accuracy or correctness of the information provided. Introba accepts no responsibility or liability for the use of the provided information.

1.05 SEISMIC REQUIREMENTS

A. Conform to requirements in Section 13 05 41 "Seismic Restraints" including required submittals described under Section 13 05 41.

1.06 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Coordinate equipment rough-in requirements with Divisions 02 through 28.

1.07 SUBMITTAL REVIEW RESPONSIBILITIES

A. General: Submittals are not requested for all products covered in the specifications. Submit only the data requested under the submittals portion of each specification section or where indicated in a Submittal Log, if included within Division 01. Un-requested submittals will not be processed or reviewed and will be returned to the submitter. Refer to “Submittal Register” for all required submissions of each specification section. All required submissions of that specification section are to be submitted for review in one all-inclusive submission. Any deviation from specified items is considered a substitution.
   1. Non-requirement of submittals, when so noted, is not to be construed as an allowance for substitutions and does not provide relief from full compliance with the contract documents.
   2. Any deviation from specified items is considered a substitution. A formal request for substitution must be submitted prior to bid date (no exceptions), in accordance with the procedures and time limitations set forth in Division 02 if the use of other than specified items is being proposed. Where not defined in Division 01, requests for substitutions shall be submitted no less than ten (10) working days prior to bid date. The submitter must pay the engineer for review of substitution requests. Charges for this substitution review will be calculated based on the Engineer’s standard hourly rates, as defined in their contract with the Owner.

B. Definitions:
   1. Product Data: Pre-printed manufacturer's data.
   2. Shop Drawings: Drawings made specifically for the manufacture of a particular piece of equipment to be used on this project.
   3. Operation and Maintenance Data: Information containing instructions on the proper operation, maintenance and repair of the equipment, complete with written text, diagrams, photos, exploded views and parts lists.
   4. Record Documents: Information indicating the actual installed conditions of the project on Mylar, electronic media, photographs or typed paper. Photographs are not allowed as a substitute for correcting the construction documents; the photographs are for the Owner’s future reference. Submit type, quantities and on media specified where indicated to be submitted.

C. Where more than one model is shown on a manufacturer’s sheet, clearly indicate exactly which item and which data is relevant to the work.

D. Where the manufacturer lists multiple part numbers or options on a single data sheet, the part number and options to be used shall be clearly set apart from other part numbers shown on that sheet.

E. Ensure that all submittals have been reviewed for total completeness and accuracy as to the requirements of the specifications and drawings before being submitted to the Engineer for review. The Contractor’s approval stamp is required on all submittals before submittal to the Engineer. Approval will indicate the Contractor’s review of all material and a complete understanding of exactly what is to be furnished. Clearly mark all deviations from the contract documents on all submittals. The item shall be required to meet all drawing and specification requirements if deviations are not clearly marked.
   1. One comprehensive submittal shall be provided for each individual specification section. All required submittal information called for in each individual specification section shall be included in the submittal. Partial or incomplete submissions will be rejected.

2. The Engineer shall not be responsible for informing the submitter on items that have not been included and are necessary for a complete review of the required submittal information for a specification section.
3. The Engineer shall have the option of returning any submittal, unmarked, if all required documentation called for in the specifications has not been provided in the submittal.
4. The Engineer shall review each submittal no more than two times and return to the submitter with the appropriate disposition.
5. If the Engineer is required to review a submittal a second time, it will be limited to review of the changed information, which must clearly be highlighted by the submitter. The submittal will be returned to the submitter with the appropriate disposition.
6. If the submittal is required to be reviewed a third time, it shall be done at the expense of the submitter. Charges for this additional submittal review will be calculated based on the Engineer's standard hourly rates, as defined in their contract with the Owner.

F. Operation and Maintenance Manuals: All items required for insertion into each Operation and Maintenance (O&M) Manual are called out in the submittals portion of each specification section or in a Submittal Log, if included within Division 01. Ensure that the O&M submittal has been reviewed and includes all the requirements of the specifications. Submit only the data requested under the submittals portion of each specification section. FAX or photo copies are not allowed as submittals for operating and maintenance manuals. The Engineer will review the submittal for the Operation and Maintenance Manual one time and return to the submitter with the appropriate disposition.
   1. If the submittal is required to be reviewed a second time, it shall be done at the expense of the submitter. Charges for this additional submittal review will be calculated based on the Engineer's standard hourly rates, as defined in their contract with the Owner.
   2. Submittals for the Operation and Maintenance Manual must be original documentation.
   3. Photo copies of marked up Operations and Maintenance submittals are not acceptable.

G. Coordination Drawings: Prepare and submit Coordination Drawings as further described herein and as indicated in the Special Conditions. Provide the Engineer with one copy of all coordination drawings supplied to the Owner when required in this specification. Coordinate the work as outlined herein. Receipt by the Engineer of a copy of the coordination drawings is to verify conformance to the submittal requirements set forth in this specification section. It is not an admission by the Engineer as to the accuracy or completeness of the coordination proposed.

H. Refer to Division 01 and each individual Division 26, 27, and 28 Section for additional submittal requirements.

1.08 PRODUCT OPTIONS AND MATERIAL SUBSTITUTIONS

A. Where two or more materials are listed in the "Part 2 – Products" subsection of any Division 26, 27 or 28 section, do not assume that the selection of materials is an option. Refer to "Part 3 – Execution" subsection of that same specification section for an explanation of which specific material(s) shall be used for which specific application(s). For example, Part 2 may list several types and grades of conductors, and Part 3 will describe which type and grade of conductors to use for a given application.

B. When two or more items of same material or equipment are required they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, wire, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in Work except as otherwise indicated.

C. Provide products which are compatible within systems and other connected items.

D. Substitutions: Products other than those specified must be submitted, approved and secured in writing from the Engineer via Addendum. If requested, a sample of the proposed substitution must be submitted to the Engineer for evaluation. This sample shall be supplied at no cost to

the Engineer, and will be returned to the submitter, at the submitter's expense at the end of the evaluation period.

E. Where several manufacturers' names are given, the manufacturer for which a catalog number is given is the basis of design and establishes the quality required.

F. Any material, article or equipment of other unnamed manufactures which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Engineer via Addendum. Assume all costs incurred as a result of using the offered material, article or equipment, including the part of other Divisions whose work is affected.

G. Voluntary add or deduct prices for alternate materials may be listed on the bid form. These items will not be used in determining the low bidder. Assume all costs incurred as a result of using the offered material or equipment on his part or on the part of other Divisions whose work is affected.

H. All material substitutions requested after the final Addendum must be listed as voluntary changes on the bid form.

1.09 PRODUCT, DELIVERY, STORAGE, HANDLING AND MAINTENANCE

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage and handling. Protect stored equipment and materials from damage.

B. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations. Review the site prior to bid for path locations and any required building modifications to allow movement of equipment.

C. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

D. Keep all materials clean, dry and free from damaging environments.

1.10 MISCELLANEOUS MATERIALS

A. Miscellaneous Materials Include:
   1. Miscellaneous metals for support of electrical materials and equipment.
   2. Wood grounds, nailers, blocking, fasteners and anchorage for support of electrical materials and equipment.
   3. Concrete bases for equipment.
   4. Sealers for sealing around electrical materials and equipment; and for sealing penetrations in floors and walls.
   5. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.11 WARRANTIES

A. Refer to the Division 01 "Closeout Procedures" for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Compile and assemble the warranties specified in Divisions 26, 27 and 28 into a separated set of vinyl covered, three-ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

D. Warranty requires correction of all work found to be defective or nonconforming to the Contract Documents, without cost to the Owner. Bear all costs associated with corrective measures and

damage due to defects or nonconformance with the Contract Documents, excluding repairs required as a result of improper maintenance or operation, or normal wear and tear as determined by the Engineer.

PART 2 - PRODUCTS

2.01 MISCELLANEOUS LUMBER

A. All lumber shall be fire-treated.

B. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative-treated in accordance with AWPB LP-2, and kiln-dried to a moisture content of not more than 19 percent.

2.02 ACCESS DOORS

A. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.

B. Frames: 16-gage steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile or wood paneling.

C. For Installation in Masonry, Concrete, Ceramic Tile, or Wood Paneling: 1 inch-wide-exposed perimeter flange and adjustable metal masonry anchors.

D. For Gypsum Wallboard or Plaster: Perforated flanges with wallboard bead.

E. Flush Panel Doors: 14-gage sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.

F. Fire-Rated Units: Insulated flush panel doors with continuous piano hinge and self-closing mechanism.

G. Locking Devices: Flush, screwdriver-operated cam locks.

H. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bar-Co., Inc.
   2. J.L. Industries.
   3. Karp Associates, Inc.
   4. Milcor Div. Inryco, Inc.
   5. Nystrom, Inc.

2.03 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.
   1. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.
   2. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section “Penetration Firestopping.”

2.04 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. Manufacturers: Subject to compliance with requirements. Provide products by one of the following

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. GPT Link-Seal
d. Metraflex Co.
e. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.
5. Place head end of bolts on accessible side of wall to allow for future adjustments.

2.05 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time and recommended for interior and exterior applications.

PART 3 - EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounted items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right-of-Way: Give to piping systems installed at a required slope.

F. Jobsite Safety: The Contractor is the sole entity responsible for jobsite safety.

3.02 EXAMINATION

A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of sealants and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Install equipment and materials in accordance with manufacturer instructions and the requirements in Section 13 05 41 "Seismic Restraints."

3.03 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Coordinate equipment rough-in requirements with Divisions 01 through 28.

3.04 ELECTRICAL INSTALLATIONS

A. Coordinate electrical equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for electrical installations.

D. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

E. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

F. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

G. Install systems, materials and equipment to conform to project requirements and approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.

H. Systems, materials and equipment which will be exposed in finished areas shall be installed level and plumb, parallel and perpendicular to other building systems and components.

I. Install electrical services and overhead equipment to provide the maximum headroom possible where mounting heights are not detailed or dimensioned.

J. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. Maintain code clearances in front of and about all electrical equipment. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.

K. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems and structural components.

L. Include in the Work all labor, materials, equipment, services, apparatus and drawings (in addition to the Contract Documents) as required to complete the intended Work.

M. Control and interlock wiring shall be installed in a separate raceway and shall not be installed in the same raceway as power conductors.

N. Only new, clean and perfect equipment, apparatus, materials and supplies of latest design and manufacture shall be incorporated in the Work in order to assure an electrical system of high quality.

O. The Work required in order to obtain utility services such as telephone and electric, is delineated in these specifications and on the drawings. Unless otherwise noted, construction or connection charges (except for temporary power) by those companies shall be paid by the Owner.

P. Determine electrical utility elevations prior to installation and coordinate with other trades. Installation priorities at a minimum shall be as follows:
   1. Luminaires.
   2. Gravity flow piping, including steam and condensate.
   3. Sheet metal.
   4. Cable trays, including access space.
   5. Other piping.
   6. Conduits and wireway.

3.05 CONNECTIONS TO EQUIPMENT AND APPLIANCES

A. In many instances the drawings show an outlet box and power supply for specific equipment, be it Owner- or Contractor-furnished. It is to be understood, unless otherwise noted, that the Work includes a connection from the box to the equipment or appliance. Verify circuit conductor quantities and sizes and overcurrent device number of poles and rating as well as any special

grounding requirements, for all Owner-furnished equipment and adjust the required work accordingly.

B. Owner Furnished Equipment:
   1. Install and connect Owner-supplied items electrical items indicated on Architectural Equipment Plans and Schedules even if not shown on the electrical plans. Connect all Owner-supplied items requiring electrical connections, whether or not shown on the electrical plans. Make all electrical system connections required for fully functional units.
   2. The Owner will supply manufacturer's installation data for new equipment purchased by owner for this project.
   3. Repair all damage to Owner-furnished equipment caused during installation, to the satisfaction of the Owner.

3.06 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 01 Section "Execution." In addition to the requirements specified in Division 01, the following requirements apply:
   1. Perform cutting, fitting and patching of electrical equipment and materials required to:
      a. Uncover Work to provide for installation of ill-timed Work.
      b. Remove and replace defective Work.
      c. Remove and replace Work not conforming to requirements of the Contract Documents.
      d. Remove samples of installed Work as specified for testing.
      e. Install equipment and materials in existing structures.
      f. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to, removal of electrical items indicated to be removed and items made obsolete by the new Work.
   2. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials.
      a. Protect the structure, furnishings, finishes and adjacent materials not indicated or scheduled to be removed.
      b. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

3.07 CONCRETE BASES

A. Provide concrete bases for all floor-mounted electrical equipment, except that stand alone dry type transformers with integral floor channels may be placed without equipment bases when located in finished areas and electrical closets.

B. Form concrete equipment bases using nominal 2 inch by 4 inch framing lumber (use larger framing if larger pads, such as for engine-generators are required) with form release compounds. Locate as indicated and construct 4 inches larger in both directions than supported unit. Except where otherwise indicated, pour bases 4 inches higher than surrounding slab. Anchor or key to floor slab in accordance with Section 13 05 41 "Seismic Restraints." Chamfer top edges and corners.

C. Include all concrete materials and workmanship required for the electrical work. Materials and workmanship shall conform to the applicable standards of the Portland cement Association. Reinforce with 6-inch x 6-inch, W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at twenty-eight days.

D. Where the base is less than 12-inches from a wall, the base shall be carried to the wall to prevent a "dirt-trap."

E. Place concrete and allow to cure before installation of equipment.

3.08 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.09 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit and place wood grounds, nailers, blocking and anchorage accurately in location, alignment and elevation to support and anchor electrical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 APPLICATION OF SEALERS

A. General: Comply with sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
   1. Comply with recommendations of ASTM C 962 for use of elastomeric sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

3.11 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports with face panels plumb and level in relation to adjacent finish surfaces.

B. Adjust hardware and panels after installation for proper operation.

3.12 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable

penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.13 SLEEVE-SEAL INSTALLATION

A. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve.

B. Install to seal exterior wall penetrations.

C. Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. Provide insulated bushings at each end of sleeve. For sleeves through fire rated-wall or floor construction, apply UL-listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.

1. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

3.14 FIRESTOPPING

A. Apply rated firestopping sealants at all penetrations of fire and smoke walls; at all penetrations of floors and at other locations as noted on the drawings or where required by Code. Consider walls that are common to different abutting buildings, to different additions to buildings, and to fire and smoke separations within buildings as requiring firestopping sealant. Refer to architectural drawings.

B. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.15 PAINTING

A. Paint all electrical equipment that is marred or damaged prior to the Owner’s acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Paint equipment, conduit, boxes, hangers, etc. as covered under Division 9.

C. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with based enamel finish coat free from scratches, abrasions, chipping, etc. Verify color preference with the Engineer before ordering equipment if a color option is specified.

3.16 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner’s final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc., from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

D. Refer to the Division 01 Section "Closeout Procedures" for general requirements for final cleaning.

3.17 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.

B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement and orientation of equipment with the Owner's representative prior to setting equipment.

C. Include removal and reinstallation of equipment and devices if they were installed without regard to coordination of access requirements and without previous confirmation with the Owner's representative.

3.18 SYSTEM COMMISSIONING

A. The electrical systems shall be complete and operating. Include system start-up, testing, balancing and satisfactory system performance. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls and alarms.

1. Utilize only skilled technicians to ensure that all systems perform properly. Reimburse the Owner on a time and materials basis for services rendered at the Engineer's standard hourly rates in effect when the services are requested if the Engineer is requested to visit the job site for troubleshooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation, workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design. Pay the Owner for services required that are project-, installation- or workmanship-related. Payment is due within 30 days after services are rendered.

3.19 FIELD QUALITY CONTROL

A. General:

1. All required equipment and systems tests shall be made during and post-Construction as required.
2. All required testing instruments, meters, etc., shall be provided.
3. Technicians operating testing equipment shall be trained in testing procedures.
4. Testing shall confirm that equipment and systems provided by the Contractor have been installed properly.
5. Unsatisfactory test results shall result in revisions or replacement of equipment or settings as required to provide a system capable of meeting test requirements. Tests shall be repeated or additional tests made as necessary to confirm system capability as required by the Owner, Engineer or Authority Having Jurisdiction.

3.20 OPERATION AND MAINTENANCE DATA

A. Refer to the Division 01 Section: "Closeout Procedures" for procedures and requirements for preparation and submittal of maintenance manuals.

B. In addition to the information required by Division 01 for Maintenance Data, include the following information:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions, regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventive maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

C. Submit three (3) properly indexed and bound copies in “D” ring style notebooks, of the Operations and Maintenance Instructions to the Architect or Engineer. Make all corrections or additions required.

D. Operation and Maintenance Instructions shall include:
1. Notebooks shall be heavy duty locking three-ring binders, black in color, and incorporate clear vinyl sheet sleeves on the front cover and spine for slip-in labeling. “Peel and stick” labels are not acceptable. Sheet lifters shall be supplied at the front of each notebook. Size notebooks a minimum of 1/2 inch thicker than the material for future inserts. Label the spine and front cover of each notebook. If more than one notebook is required, label in consecutive order. For example; 1 of 2, 2 of 2. No other forms of binding will be acceptable.
2. Prepare binder covers (front and spine) with printed title “Operation and Maintenance Instructions,” title of project, and subject matter of binder when multiple binders are required.
3. Title page with project title, Architect, Engineer, Contractor, and Subcontractor with addresses, telephone numbers, and contacts.
4. Table of Contents describing all index tabs.
5. Listing of all Subcontractors and major equipment suppliers with addresses, telephone numbers and contacts.
6. Index tabs dividing information by specification section, major equipment, or systems. All tab titles shall be clearly printed under reinforced plastic tabs. Label all equipment to match the identification in the construction documents.
7. Copies of warranties.
8. Copies of all final approved shop drawings and submittals. Copy of power system study and overcurrent protective device settings.
9. Copies of all factory inspections and or equipment start-up reports.
10. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
11. Dimensional drawings of equipment.
12. Detailed parts lists, each with a list of suppliers.
13. Operating procedures for each system.
14. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
15. Repair procedures for major components.
16. Replacement parts and service material requirements for each system and the frequency of service required.
17. Instruction books, cards, and manuals furnished with the equipment.

E. Operation and maintenance data shall consist of written instructions for the care, maintenance, and operation of the equipment and systems. Instruction books, cards, manuals furnished with the equipment shall be included.

F. In addition to the information required by Division 01 for Maintenance Data, include the following information:
1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions, regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventive maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

G. Adequately instruct the Owner's designated representative in the maintenance, care, and operation of the complete systems installed under this contract.

H. Provide verbal and written instructions to the Owner's representatives by factory personnel in the care, maintenance and operation of the equipment and systems.

I. Make DVD format compact disc of the instructions to the Owner while explaining the system so additional personnel may view the instructions at a later date. The video shall become the property of the Owner.

J. The instructions shall include:
1. Maintenance of equipment.
2. Start-up procedures for all major equipment.
3. Description of emergency system operation.

K. Notify the Engineer of the time and place for the verbal instructions to the Owner's representative so his representative can be present if desired.

L. Minimum hours of instruction time for each item and/or system shall be as indicted in each individual specification section.

M. Operating Instructions:
1. Include instructions to the Owner's representatives for the electrical and specialized systems, using factory-authorized technical representatives.

3.21 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 01 Section "Closeout Procedures." In addition to the requirements specified in Division 01, indicate installed conditions for:
1. Raceways of 2-inches and larger, indicating size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Location of every home run point, such as receptacle, lighting fixture, or switch.
4. Approved substitutions, Contract modifications, and actual equipment and materials installed.
5. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; change orders; concealed control system devices.
6. Mark Specifications to indicate approved substitutions, change orders, actual equipment and materials used.

B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; Change Orders; concealed control system devices.

D. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. Mark all Change Orders, RFI responses, clarifications, and other supplemental instructions on the documents. Record documents that merely reference

the existence of the above items are not acceptable. Reimburse the Engineer for all costs for the Engineer to develop record documents which comply with this requirement if unable to comply with said above requirements. Reimbursement shall be made at the Architect or Engineer's hourly rates in effect at the time of the work.

E. Record changes daily and keep the marked drawings available for the Architect or Engineer's examination at any normal work time.

F. Upon completing the job, and before final payment is made, give the marked-up drawings to the Engineer.

3.22 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 01:

B. Final Jobsite Observation:
   1. Certify that the project jobsite is ready for the final jobsite observation.
   2. Reimburse the Engineer, based on the Engineer's standard hourly rates as defined in their contract with the Owner, for additional time and expenses when additional trips are required because the project jobsite was not ready for final observation and additional trips are required by the Engineer for review of final conditions.
   3. Notify the Engineer a minimum of two working days prior to installation of ceiling tiles or lay-in ceilings to allow the Engineer to visit the project site.

C. Submit the following documents to the Architect or Engineer prior to requesting final payment:
   1. Operation and maintenance manuals with copies of approved shop drawings.
   2. Record documents including electronic AutoCAD or REVIT drawings and specifications.
   3. Documentation of completion of all required training of Owner's personnel.
   4. Provide spare parts, maintenance and extra materials in quantities specified in individual specification sections.
   5. Inspection and testing reports.
   6. Start-up reports on all equipment requiring a factory installation or start-up.
   7. Submittals required by commissioning of the electrical systems.

END OF SECTION

SECTION 26 05 19
CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:
   1. Conductors and Cables.
   2. Metal Clad Cable (MC).
   3. Remote Control and Signal Cable.

1.03 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.04 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. Comply with NFPA 70 “National Electrical Code.”
   1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.

C. UL Compliance: Provide components which are listed and labeled by Underwriters Laboratories under the following standards.
   1. UL Std. 83 Thermoplastic-Insulated Wires and Cables.
   2. UL Std. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   3. UL Std. 1569 Metal Clad Cables.

D. NEMA and ICEA Compliance: Provide components which comply with the following standards:
   1. WC-70: Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy.

E. IEEE Compliance: Provide components which comply with the following standard.
   1. Std. 82: Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Insulated Wire Corp.; a Leviton Company.
   2. General Cable Corporation.
   3. Senator Wire & Cable Company.
   4. Southwire Company.
   5. Cerro Wire.
   6. Superior Essex.
   7. Encore Wire Corporation.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN-2.

D. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

2.02 CONDUCTORS AND CABLES

A. General: Provide wire and cable suitable for the temperature, conditions, and location where installed.

B. Feeders: Copper, 600-volt insulation. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper, 600-volt insulation. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

D. Control Circuits: Copper, stranded conductor, 600-volt insulation.

E. Wire for the following specialized systems shall be as shown on drawings or as dictated within these specifications. Where not designated, the systems manufacturer's recommendations shall be adhered to for the following systems:
   1. Fire Alarm.
   2. Data.
   3. Telephone.

F. Single Conductors for Feeders and Branch Circuits:
   1. Stranding: Provide solid conductors for branch circuits and non-vibrating power utilization equipment utilizing Number 10 AWG and smaller. Provide stranded conductors for Number 8 AWG and larger. Provide stranded conductors, regardless of size, for connections to vibrating equipment such as motors and transformers.

2.03 METAL CLAD, TYPE MC CABLE

A. General: Metal clad cables may be utilized for branch circuit wiring as defined in NFPA 70, Article 330 subject to acceptance by State and Local Codes.

B. Construction: Metal Clad cable to be a factory assembly of one or more individually insulated conductors enclosed in a metal sheath with armor ground. MC cable shall be listed and labeled under UL 1569.

C. Sheathing: Steel or aluminum interlocking tape, smooth tube or corrugated tube. Convolutions of interlocking tape shall not separate when cable is bent at a radius as tight as seven times the external diameter of the cable sheath.

D. Conductor Material: Copper, minimum 12 AWG.

E. Conductor Insulation: Minimum temperature rating of 90 degrees Celsius and of a type listed in NEC Table 310-13.

F. Metal clad cable shall **not** be used for circuits connected to the essential electrical system.

G. Approved use of metal clad cable is limited. Refer to Part 3 of this specification for permitted uses.

2.04 REMOTE CONTROL AND SIGNAL CABLE

A. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded, and covered with a PVC jacket.

B. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.

C. Plenum Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

2.05 CONNECTORS AND SPLICES

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. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type and class for application and service required.

PART 3 - EXECUTION

3.01 CONDUCTOR INSULATION, APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN-2, single conductors in raceway.

B. Concealed in Ceilings, Walls, Partitions, Raised Flooring and Crawlspaces: Type THHN-THWN-2, single conductors in raceway.

C. Concealed in Concrete, below Slabs-on-Grade and Underground: Type THWN-2, single conductors in raceway.

D. Exposed: Type THHN-THWN-2, single conductors in raceway.

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

F. Class 1 Control Circuits: Install per NEC Article 725.

G. Class 2 Control Circuits: Install per NEC Article 725.

3.02 DEVIATION FROM CONTRACT DRAWINGS

A. Basis of Design is copper conductors installed in raceway, based on 30 degrees C ambient temperature (NEC Table 310.15(B)(16)). If materials or methods selected for installation differ from the basis of design, size conductors and conduits to meet or exceed the ampacity of circuits selected for the basis of design.

B. Routing multiple conductors within a single conduit requires the conductor ampacity to be derated per National Electrical Code Article 310. Do not provide more than 4 conductors within a single conduit to serve loads such as panelboards, motor control centers, motors over 1/4 horsepower, etc.

C. Underground duct conductor ampacity is based on table B.310.15(B)(2)(7) of the National Electrical code or has been calculated in accordance with Informative Annex B: Application Information for Ampacity Calculation. Deviation from the contract documents in regard to conductor and conduit quantities or orientation shall require supporting calculations and a sketch for Engineer approval.

D. Where ungrounded conductors are increased in size for any reason, equipment grounding conductors shall be increased in size proportionally according to the circular mil area of the ungrounded conductors.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

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

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

C. Completely and thoroughly swab raceway before installing wire.

D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Use pulling means including fish tape, cable, rope, and basket weave wire and cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable. Do not exceed maximum tensile strength of conductor or grip. Do not exceed maximum sidewall pressure limitations of cables.

F. Pull conductors simultaneously where more than one is being installed in the same raceway.

G. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

H. Feeder conductors shall be continuous and shall not contain splices.

I. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than Number 10 AWG cabled in individual circuits. Make terminations so there is no more than 1/8 inch of exposed bare conductor at the terminal. Observe NEC 310.15 (B)(2)(a) adjustment factors.

J. Verify that interior of building has been protected from weather and mechanical work likely to damage wire and cable has been completed prior to installing wire and cable.

K. Use conductor not smaller than Number 12 AWG for power and lighting circuits.

L. Single conductors used for control circuits shall not be smaller than Number 14 AWG.

M. Use Number 10 AWG conductors (phase, neutral and ground) for 20 ampere, 120 volt branch circuits longer than 75 feet, unless drawings requirements are more stringent.

N. Use Number 10 AWG conductors (phase, neutral and ground) for 20 ampere, 277 volt branch circuits longer than 200 feet, unless drawings requirements are more stringent.

O. Use Number 8 AWG conductors (phase, neutral and ground) or larger for outdoor lighting circuits.

P. Place an equal number of conductors for each phase, neutral and ground of a circuit within the same raceway or cable when routing parallel conductors. Conductor lengths must be equal.

Q. Support cables according to Division 26 Section "Hangers and Supports."

R. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.04 CABLE INSTALLATION, APPLICATIONS AND WIRING METHODS

A. Open cabling shall be routed in a symmetrical manner, tight and parallel to walls.

B. Support open cable by appropriate size bridle rings or j-hooks at five-foot intervals. Open cable may not rest on suspended ceilings. Wire and cable from different systems shall not be installed within the same bridle rings or j-hooks. Neatly bundle grouped cables every two-and-a-half foot with a nylon tie wrap.

C. Open cable may only be installed where specifically dictated on drawings or permitted elsewhere within these specifications.

3.05 METAL CLAD CABLE INSTALLATION

A. Metal clad cables may be utilized for 20A and 15A branch circuit wiring as defined in NFPA 70, Article 330 and Article 517 subject to acceptance by State and Local Codes. Feeder wiring must consist of individual insulated conductors in conduit.

B. Metal clad cable installations shall comply with the requirements stipulated within Article 330 of the National Electrical Code.

C. Provide individual insulated conductors in conduit from branch panelboard to junction box(es) located above the ceiling in the same room as the final device(s) or luminaire(s) being served.

1. Metal clad cable is permitted to be extended from this junction box to electrical devices and luminaires in the same room where all other requirements of this specification are met. Horizontal length of HCF metal clad cable extending from the local room junction box to the final in-wall device shall not exceed 25 feet.

2. In rooms or spaces with inaccessible ceilings, the aforementioned junction box may be located in the nearest accessible ceiling, corridor preferred.

D. Metal clad cable is allowed for flexible connection to luminaires in lengths not to exceed 6’-0”.

E. Metal clad cable is allowed for branch circuits of 30 amperes and less when run from a junction box located above an accessible ceiling, within 8 feet of the partition containing the served wiring device box (or within 6 feet of a lighting fixture). Wiring between the above junction box and the panelboard shall consist of individual conductors in conduit.

F. Metal clad cable shall only be run concealed.

G. Metal clad cable shall not be daisy chained from [receptacle-to-receptacle or from] luminaire to luminaire. Metal clad cable runs shall be from a junction box to the final device or luminaire.

H. Metal clad cable shall **not** be used for circuits serving the Essential Electrical System.

3.06 CONNECTIONS AND TERMINATIONS

A. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.

B. Clean conductor surfaces before installing lugs and connectors.

C. Utilize solderless compression terminals applied with circumferential compression for conductor sizes 8 AWG and larger and crimp in accordance with manufacturer instructions. Indenter compression method may be used for conductor sizes 10 AWG and smaller.

D. Phase Sequence: Connections to phase conductors at electrical equipment shall be made such that the A-B-C conductors, when facing the equipment, are oriented top to bottom, or left to right.

E. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.07 SPLICES AND TAPS

A. Conductor splices shall be kept to a minimum.

B. Only splice within accessible junction boxes or enclosures.

C. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors. Splices and taps shall be capable of carrying the full ampacity of the conductors without perceptible temperature rise.

D. Above Grade:
1. Use copper compression connectors applied with circumferential compression for conductor sizes 6 AWG and larger.
2. Use pre-molded insulated tap connectors for copper conductor splices and taps, Number 8 AWG and smaller. Insulate with UL listed insulating cover supplied by same manufacturer as connector.
3. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, Number 10 AWG and smaller.
4. Tape uninsulated conductors and connectors with electrical tape to 150 percent of insulation rating of conductor, or three layers of tape, whichever is greater.

E. Below Grade:
1. Use specified insulated connectors suitable and approved for below grade wiring connectors. Ensure that conductors do not apply tension to splice.

3.08 FIELD QUALITY CONTROL

A. Inspect wire for physical damage and proper connection.

B. Measure tightness of bolted connections with properly scaled and calibrated torque tool and compare torque measurements with manufacturer's recommended values.

C. Before energizing, test wires and cables for electrical continuity and for short circuits.

D. Remove and replace malfunctioning conductors and retest as specified above.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

1.03 SUBMITTALS

A. Submittals for approval by the Engineer of products to be used are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

B. Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Grounding arrangements and connections for separately derived systems.
   4. Grounding for sensitive electronic equipment.

C. Field Test Reports: Submit written test reports to include the following:
   1. Test procedures used.
   2. Weather and soil conditions observed on test date.
   3. Test results that comply with requirements.
   4. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.04 QUALITY ASSURANCE

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled for the specific purposes by Underwriters Laboratories.

PART 2 - PRODUCTS

2.01 GROUNDING AND BONDING PRODUCTS

A. Products: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

2.02 CONDUCTORS

A. General: Comply with Division 26 Section "Conductors and Cables" for insulated grounding conductors. Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.

B. Equipment Grounding Conductor: Green insulated; conductor metal shall match branch circuit conductor metal.

C. Grounding Electrode Conductor: Stranded cable.

D. Underground Conductors: Bare, stranded copper except as otherwise indicated.

E. Copper Conductors: Conform to the following:
   1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
   2. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   3. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
   4. Bonding Strap Conductor/Connectors: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

2.03 GROUNDING BUS

A. Predrilled rectangular bars of annealed copper, 1/4-inch by 6 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.04 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure (clamp) type with at least two bolts.

C. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Pressure Connectors: High-conductivity-plated units.

E. Bolted Clamps: Heavy-duty units listed for the application.

F. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

G. Compression Connectors: Irreversible compression connectors must be factory filled with oxide inhibitor and fully crimped with a 14-ton or larger hydraulic tool so that index number is embossed on the connector. May be used above or below grade.

H. Lightning Protection Aluminum-To-Copper Connections: Bimetallic type, conforming to UL 96, "Lighting Protection Components," or UL 467.

2.05 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.
   1. Size: 3/4 inch diameter by 10 feet length.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Route grounding electrode conductors within rigid polyvinyl chloride (PVC) conduit.

C. Seal all exterior wall penetrations air tight.

D. Do not use aluminum conductors in direct contact with earth, concrete, masonry or similar materials.

3.02 GROUNDING ELECTRODES

A. Ground Rods: Provide a minimum of two ground rods separated no less than 20 feet from each other.

1. Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
2. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any. Utilize exothermic welds where ground rods are not provided within test wells.

B. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors in conduit from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

C. Utility Metering (Ameren) Equipment: Provide bonding conductor at utility company (Ameren) metering equipment and pad mounted transformer per utility company requirements.

3.03 GROUNDING BUS

A. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment and elsewhere as indicated.
1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

3.04 EQUIPMENT GROUNDING

A. Equipment Grounding Conductor Application: Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated.

A. Install separate insulated equipment grounding conductors with all feeders and branch circuit conductors. Terminate each end on a grounding lug or bus.

3.05 BONDING

A. Air Duct Equipment Circuits: Install an insulated equipment grounding conductor to duct-mounted electrical devices operating at 120-V and above including air cleaners and heaters. Bond the conductor to each such unit and to the air duct.

B. Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, pumps, blowers, electric heaters and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

C. Water Heater, Heat Tracing, and Anti-Frost Heater Circuits: Install separate insulated equipment ground conductor to each electric water heater, heat tracing and surface anti-frost heating cable. Bond this conductor to heater units, piping and connected equipment and components.

D. Building Expansion Joints: Provide flexible bonding jumper between columns and beams on both sides of each expansion joint.

E. Separately Derived Systems: Where the NEC requires separately derived systems to be grounded, provide grounding in accordance with the NEC.

F. Connection to Other Systems: Bond electrical system grounding, lightning protection, telephone, CATV, other communications systems, metal water piping, metal gas piping and other piping systems together.

G. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
   1. For telephone, alarm, voice and data and other communication equipment, provide No. 3/0 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet and central equipment location.
   2. Main Telecommunication Service and Telecommunication Closets: Terminate grounding conductor on a 1/4-inch by-4-inch by-24-inch grounding bus.
   3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

H. Lightning Protection System Common Ground Bonding: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized the same as system grounding electrode conductor and install in conduit.

I. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

J. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

K. Braided-Type Bonding Jumpers: Install to connect ground clamps on water meter piping to bypass water meters electrically. Use elsewhere for flexible bonding and grounding connections.

3.06 CONNECTIONS

A. General: Select connectors, hardware and conductors and make connections in such a manner as to minimize possibility of galvanic action or electrolysis.
   1. Make connections with clean bare metal at points of contact.
   2. Aluminum to steel connections shall be with stainless steel separators and mechanical clamps.
   3. Aluminum to galvanized steel connections shall be with tin-plated copper jumpers and mechanical clamps.
   4. Coat and seal connections involving dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
   5. Exothermic Welded Connections or Compression-type Connections: Use for connections to structural steel and for underground connections except those at test wells. Install at connections to ground rods and plate electrodes. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable. Compression connections should be inspected for visible die index number matching the die and connector used. Connections that do not show this are not acceptable.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Exothermic-welded or compression-type connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Exothermic-welded or compression-type ground stud connector.

C. Equipment Grounding Conductors: Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs.

D. Metallic Raceway Continuity: Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

E. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A.

F. Compression-Type Connections: Use hydraulic compression tools of at least 14-ton size to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.

3.07 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG minimum.
1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Handholes: Install a driven ground rod through handhole floor, close to wall and set rod depth so 4 inches will extend above finished floor. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

E. Grounding System: Ground non-current-carrying metallic items associated with pad-mounted equipment by connecting them to bare underground cable and grounding electrodes arranged as indicated.

3.08 FIELD QUALITY CONTROL

A. Tests and Inspections: After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements:
1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.
    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.
3. Prepare dimensioned drawings locating each test well, ground rod and ground-rod assembly and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
4. Maximum Ground Resistance Values:
    a. Service neutral to reference ground: 5 Ohms
    b. Equipment rated 500 kVA and Less: 10 Ohms.
    c. Equipment rated 500 to 1000 kVA: 5 Ohms.
    d. Equipment rated greater than 1000 kVA: 3 Ohms.
    e. Substations and Pad-Mounted Equipment: 5 Ohms.
5. Where resistance to ground exceeds specified values, notify Engineer and include recommendations to reduce ground resistance.

B. Restore surface features at areas disturbed by excavation and reestablish original grades except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other Work to their original condition. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching. Perform such Work in accordance with Division 32. Maintain disturbed surfaces. Restore vegetation in accordance with the requirements of that Division. Restore disturbed paving as indicated.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Specification Section 13 05 41 “Seismic Restraints” apply to this section.

1.02 SUMMARY

A. This Section includes the following:
   1. Secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals and associated fastenings.
   2. Construction requirements for concrete bases.

1.03 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. RMC: Rigid metal conduit.

C. RNC: Rigid non-metallic conduit.

D. Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of four times the applied force.

1.04 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.05 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Electrical components shall be listed and labeled for the specific intended purpose by Underwriters Laboratories, Inc.

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

1.06 COORDINATION

A. Coordinate size, shape and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Slotted Metal Angle and U-Channel Systems:
      a. Allied Tube & Conduit.
      b. American Electric.
      c. B-Line Systems, Inc.
      d. GS Metals Corp.
      e. Unistrut Diversified Products.
   2. Conduit Sealing Bushings:
      a. Bridgeport Fittings, Inc.
      b. Killark Electric Mfg. Co.
      c. O-Z/Gedney.

d. Raco, Inc.
e. Red Seal Electric Corp.

2.02 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish or inherent material characteristic.

2.03 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets and spring steel clamps.

B. Fasteners: Types, materials and construction features as follows:
   1. Expansion Anchors: Carbon steel wedge or sleeve type.
   2. Toggle Bolts: All steel springhead type.
   3. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-gauge steel channels, with 9/16-inch-diameter holes, between one and one half and two and one half inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.04 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves:
   1. Provide pipe sleeves of one of the following:
      a. Interior Dry Locations: Fabricate from Schedule 40 galvanized steel pipe or Schedule 40 PVC plastic pipe.
      b. Exterior or Interior Wet or Damp Locations: Fabricate from Schedule 40 PVC plastic pipe.
   2. Sleeves shall not penetrate structural members without approval from the Structural Engineer.
   3. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.
   4. Install all sleeves concentric with conduits. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.
   5. Where conduits rise through concrete floors that are on earthen grade, provide 3/4-inch resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete at the point of penetration. Secure to prevent shifting during concrete placement and finishing.
   6. Size sleeves large enough to allow expansion and contraction movement.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other disciplines' installations.

C. Raceway Supports: Comply with the NEC and the following requirements:
   1. Conform to manufacturer's recommendations for selection and installation of supports.
   2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.
   3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
   4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
   5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-inch and smaller raceways serving branch circuits, telephone and data above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
   6. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
   7. Support exposed and concealed raceway within 3 feet of boxes, access fittings, device boxes or cabinets.
   8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway or conductor terminals.
   9. Vertical Conductor Supports: Install simultaneously with installation of conductors.
   10. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers and other devices.

D. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, motor control centers, disconnect switches and control components in accordance with the following:
   1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
   2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4-inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
   3. Do not fasten supports to ceiling systems, piping, ductwork, mechanical equipment or conduit unless otherwise noted.
   4. Do not use powder-actuated anchors without specific permission.
   5. Do not drill structural steel members.
   6. Install surface-mounted cabinets and panelboards with minimum of four anchors.
   7. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

E. In wet locations and on all building floors below exterior earth grade install freestanding electrical equipment on concrete pads.

F. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.02 PAINTING

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

TABLE I: SPACING FOR RACEWAY SUPPORTS

			Maximum Spacing of Supports (Feet)		
Raceway Size (Inches)	**No. of Conduits in Run**	**Location**	**RMC**	**EMT**	**RNC**
HORIZONTAL RUNS					
1/2, 3/4	1 or 2	Flat ceiling or wall.	5	5	3
1/2, 3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7	--
1/2, 3/4, 1	3 or more	Any location.	7	7	--
1 & larger	1 or 2	Flat ceiling or wall.	6	6	--
1 & larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10	--
1 & larger	3 or more	Any location.	10	10	--
Any	--	Concealed.	10	10	--
VERTICAL RUNS					
1/2, 3/4	--	Exposed.	7	7	--
1, 1-1/4	--	Exposed.	8	8	--
1-1/2 and larger	--	Exposed.	10	10	--
Up to 2	--	Shaftway.	14	10	--
2-1/2	--	Shaftway.	16	10	--
3 & larger	--	Shaftway.	20	10	--
Any	--	Concealed.	10	10	--

END OF SECTION

SECTION 26 05 33
RACEWAYS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following raceways electrical wiring:
   1. Metallic Conduit and Tubing.
   2. Non-Metallic Conduit and Tubing.
   3. Metal Wireways.
   4. Power Poles.
   5. Low Voltage Cabling Support.
   6. Communications Raceway Accessories.

1.03 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.04 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. Comply with NFPA 70 "National Electrical Code" for components and installation.

C. Comply with NECA "Standard of Installation."

D. Listing and Labeling: Provide products specified in this Section that are listed and labeled by Underwriters Laboratories for the specific purpose and comply with the following standards:
   1. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
   2. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated.
   3. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
   4. ANSI/NFPA 70 - National Electrical Code.
   5. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.
   6. NECA "Standard of Installation."
   7. NEMA TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
   8. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.
   9. NEMA TC 6 - PVC and ABS Plastic Utilities Duct for Underground Installation.
   10. NEMA TC 9 – Fittings for PVC Plastic Utilities Duct for Underground Installation.
   11. TIA/EIA-569-A – Commercial Building Standard for Telecommunications pathways and spaces.
   12. TIA/EIA-606-E – The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings.
   13. “Telecommunications Distribution Methods Manual” published by the Building Industry Consulting Services International (BICSI).

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Provide conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for each service indicated. Where types and grades are not indicated, provide proper selection determined by installer to fulfill wiring requirements, and comply with applicable portions of NFPA 70 for raceways.

B. Bushings: Bushings for terminating conduits smaller than 1-1/4 inches are to have flared bottom and ribbed sides, with smooth upper edges to prevent injury to cable insulation. Install insulated type bushings for terminating conduits 1-1/4 inches and larger. Upper edge to have phenolic insulating ring molded into bushing. Bushings to have screw type grounding terminal.

C. Raintight Sealing Hubs: Two piece type with outer internally-threaded hub to receive conduit, inner locking ring with bonding screw, insulated throat, and V-shaped ring or O-ring.

2.02 METAL CONDUIT AND TUBING

A. Rigid Steel (Metallic) Conduit:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. LTV Steel Tubular Products Company.
      c. O-Z Gedney.
      d. Wheatland Tube Company.
   2. Description: Conduit to be seamless, hot dipped galvanized rigid steel. Threads to be cut and ends chamfered prior to galvanizing. Galvanizing to provide zinc coating fused to inside and outside walls of conduit. Provide an enamel lubricating coating on the inside of the conduit. Conduit to conform to ANSI C80.1 and listed and labeled under UL 6.
   3. Fittings and Conduit Bodies: NEMA FB 1, single piece threaded, cadmium plated malleable iron.
      a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
   4. Joint Compound: Listed for use in cable connector assemblies and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

B. Electrical Metallic Tubing:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. Republic Conduit.
      c. Wheatland Tube Company.
   2. Description: Conduit to be seamless, hot dipped or electro-galvanized steel tubing. Galvanizing to provide zinc coating fused to outside walls of conduit. Provide an enamel lubricating coating on the inside of the conduit. Conduit to conform to ANSI C80.3 - 1983 and listed and labeled under UL 797.
   3. Fittings and Conduit Bodies: Compression.
      a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
   4. Expansion fittings for use with EMT shall allow for a minimum of four inches of movement and shall be like O-Z Gedney TX series, complete with bonding jumpers and hardware.

C. Flexible Metal Conduit: Zinc-coated steel or aluminum.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AFC Cable Systems.
      b. Alflex Inc.
      c. Electri-Flex Co.

2. Description: Interlocked steel or aluminum construction, consisting of spirally wrapped, convoluted hot dip galvanized steel strip. Zinc coating to cover both sides and all edges of steel strip. Convolutions to be interlocked to prevent separation when conduit is bent at radius equal to 4-1/2 times conduit O.D. Conduit to be listed and labeled under UL 1.
3. Fittings: ANSI/NEMA FB 1 -1988. Threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron.

D. Liquidtight Flexible Metal Conduit:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AFC Cable Systems.
b. Alflex Inc.
c. Electri-Flex Co.
2. Description: Flexible steel conduit with PVC jacket, listed and labeled under UL 360
3. Fittings: and Conduit Bodies: Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron. Conduit to be listed and labeled under UL 360.

2.03 NONMETALLIC CONDUIT AND TUBING

A. Rigid Non-Metallic Conduit:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Cantex.
b. J.M. Manufacturing.
c. Allied Tube & Conduit.
d. Lamson & Sessions; Carlon Electrical Products.
2. Description: Conduit to be PVC, Schedule 40 or Schedule 80 as indicated, rated for use with 90 degrees C conductors and suited for direct burial and above ground use in direct sunlight, whether encased in concrete or not. Conduit to conform to latest edition of ASTM F512, NEMA TC-2, and be listed and labeled under UL 651.
3. Fittings and Conduit Bodies: Manufactured per NEMA TC-3 and UL 651 listed to match conduit, type and material. Expansion fittings shall allow for six inch movement, and shall be similar to Carlon E945 series. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

2.04 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, 12, or 3R as environmental conditions dictate, unless otherwise indicated.

C. Material: Primed and painted sheet steel for indoor locations, galvanized sheet steel for outdoor locations sized as indicated or required, whichever is greater.
1. Wireway up to 6 inch by 6 inch cross section shall be minimum 16 gage.
2. Wireway larger than 6 inch by 6 inch cross section shall be minimum 14 gage.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

E. Wireway Covers: Screw-cover type. Utilize flanged-and-gasketed type for outdoor locations.

F. Finish: Manufacturer's standard gray enamel finish.

2.05 POWER POLES

A. Construction:
   1. Two compartments.
   2. Height:
      a. Extend a minimum of 6 inches above accessible ceiling.
   3. Dimensions
      a. Power Compartment: 2-1/4 inches x 1-1/4 inches.
      b. Communications Compartment: 2-1/4 inches x 1-1/4 inches.
   4. Removable covers.

B. Provide mounting hardware, entrance end fitting, and ceiling trim plate.

C. Manufacturers:
   1. Wiremold.
   2. Panduit.
   3. Hubbell.

2.06 LOW VOLTAGE CABLING SUPPORT

A. General: The following supporting products are for use in systems below 50V.

B. Open top cable supports (J-Hooks):
   1. Galvanized steel construction with smooth rounded edges.
   2. Complies with UL, cUL, NEC, and ANSI/TIA/EIA requirements for structured cabling systems.
   3. Manufacturers:
      a. Erico.
      b. B-Line.
      c. Panduit.

2.07 COMMUNICATIONS RACEWAY ACCESSORIES

A. Pull cords:
   1. Pull wires shall be nylon type.
   2. Provide in all empty conduits, sleeves, raceways and all cabling pathways for future use.
   3. Pull cords shall have a tensile rating of 200 pounds minimum.

B. Fiber Optic Innerduct:
   1. NEMA TC 5, UL listed, corrugated, specifically designed for optical fiber cable pathways.
   2. Fiber optic innerduct shall be orange in color.
   3. Innerduct shall be 1-inch minimum inside diameter, and a minimum pulling strength of 600 pounds.
   4. Each innerduct shall include a factory installed pull rope.
   5. Each duct shall be suited for the environment in which it is installed.
   6. Manufacturers:
      a. Carlon.
      b. Arnco.
      c. Opti-Com.
      d. Maxcell.

C. Cable Spillways:
   1. Provide Spillway on sleeves 2 inches and greater.
   2. Manufacturers:
      a. Bejed.
      b. BLine.
      c. Panduit.

PART 3 - EXECUTION

3.01 METALLIC AND NON-METALLIC CONDUIT APPLICATION

A. The following schedule shall be followed for all installations unless it creates a violation of applicable codes or is otherwise specifically dictated otherwise within the drawings.
   1. Outdoor Locations Above Grade (Including Roofs): RMC
   2. Indoor Locations:
      a. Exposed, not subject to physical damage, or above 7 feet-0 inches of finished floor: RMC or EMT.
      b. Exposed, subject to physical damage, or within 7 feet-0 inches of finished floor: RMC.
      c. Finished spaces, concealed above suspended ceilings and interior walls and partitions: EMT.
      d. Wet or Damp Locations: RMC.
   3. Connections to vibrating equipment: FMC, except use LFMC in wet or damp locations.
   4. Under Slabs on Grade or Site Conduits :
      a. Within 5 feet-0 inches of the building perimeter: RMC or Concrete Encased RNC.
      b. Greater than 5 feet-0 inches of the building perimeter: RNC or Concrete Encased RNC.
   5. Optical Fiber or Communications Cable: EMT or Flexible type, listed for purpose.
   6. Hazardous Locations: As defined by the National Electrical Code, RMC conduit with screwed fittings and conduit seals.

B. Conduit Size:
   1. Conduits shall be sized as shown on drawings. Where conduit sizes are not indicated, conduits shall be sized in accordance with the latest version of the National Electrical Code (NFPA 70) and shall be limited to a 40 percent conductor fill percentage. Conductor ampacities must be maintained; therefore adjustment factors for temperature and quantity derating values must be observed.
      a. Minimum Conduit Size: Unless otherwise noted, 1/2-inch trade size with the following exceptions:
         1) Switchlegs, Luminaire Whips and Control Wiring: 1/2-inch.
         2) Below Grade: 1-inch.
      b. Conduit sizes may change only at the entrance or exit of a junction box.

3.02 METALLIC AND NON-METALLIC CONDUIT INSTALLATION

A. General Installation Requirements
   1. Conduits shall be mechanically and electrically continuous from source of current to all outlets unless a properly sizes grounding conductor is routed within the conduit. All metallic conduits shall be bonded per NFPA 70.
   2. Do not reduce the indicated sizes of raceways. Conduit sizes may only change junction and pull boxes.
   3. Complete raceway installation before starting conductor installation.
   4. Use temporary closures to prevent foreign matter from entering raceway.
   5. Avoid moisture traps; provide junction box with drain fitting at low points in raceway system.
   6. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Empty raceways shall be labeled at each end indicating origin of the raceway. Labels shall be self-adhesive vinyl labels.
   7. Raceways containing feeders and circuits associated with the emergency power system and the standby power system must be kept entirely independent from each other and other sources of power.

B. Conduit Routing:

1. Conduit shall be concealed in walls and above ceilings within finished spaces and may be exposed within unfinished spaces (such as mechanical and utility areas) where conditions dictate and as practical. Where routed exposed, headroom shall be maintained for pedestrian and vehicular traffic.
2. Raceway routing proposed on Drawings is diagrammatic in nature and shown in approximate locations unless dimensioned. Coordinate conduit routing with beams, joists, columns, windows, etc., as required to complete wiring system. Verify field measurements, routing and termination locations of raceway with obstructions and other trades prior to rough-in.
3. Conduit installation shall be coordinated with all other systems on the project. The Construction Team shall exchange details of their work in order to ensure adequate and coordinated fit of all systems within ceiling spaces and exposed unfinished areas.
4. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions, except as otherwise indicated.
5. Route exposed conduit and conduits above ceilings parallel and perpendicular to building structural lines, and as close to building structure as possible.
6. Raceways are not to cross pipe shafts or ventilating duct openings, nor are they to pass through HVAC ducts. Support riser raceway at each floor level with clamp hangers. Maintain adequate clearance between raceway and piping.
7. Coordinate layout and installation of conduit with other construction elements to ensure adequate headroom, working clearance and access.
8. Route conduit through roof openings provided for piping and ductwork or rooftop unit curbs where possible. Where unavoidable, route conduit through suitable roof jack with pitch pocket. Coordinate roof penetrations with other trades.
9. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water
10. Raceways routed under-slab on grade must be a minimum of 12 inches below the concrete slab.

C. Conduit Supports:
   1. Install raceways level and square and at proper elevations. Provide adequate headroom. Group related conduits; support using conduit rack. Construct rack using steel channel. All conduit supports shall be secured to walls, structural members, and bar joists. Do not support conduits from non-structural members, such as ductwork, water or fire suppression piping, or ceiling grid support system.
   1. Run parallel or banked raceways together, on common support racks where practical and make bends from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways. Provide space within each rack for 20 percent additional conduits.
   2. Support raceways as specified in Division 26 Section "Hangers and Supports."

D. Conduit Fittings and Terminations:
   1. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
   2. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
   3. Install raceway sealing fittings according to the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank coverplate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings where conduits enter or leave hazardous locations, where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces, such

as kitchen cold boxes, air-conditioned spaces and other places indicated on the drawings or required by NFPA 70.

4. Expansion/Deflection Joints: Provide suitable fittings to accommodate expansion and contraction where raceway crosses seismic and expansion joints. Install expansion fittings in the full open position if installed during a period of lowest expected temperature, and in the fully closed position if installed during a period of highest expected temperature. Install at proportionate intermediate position for intermediate temperatures.
   a. In addition to the foregoing, provide expansion fittings according to the following table, for exposed linear runs or runs in hung ceilings where such runs do not contain junction boxes, pull boxes, nor bends totaling more than 30 degrees.
   b. EMT and RMC expansion couplers shall be UL listed with an internal copper braided bonding jumper that meets the requirements of NEC 250.98. Fitting shall be listed as suitable for wet locations and rain water tight when installed in wet or outdoor locations.

Raceway Material	Indoor, conditioned areas	Outdoors and non-conditioned areas
Steel	One expansion fitting in runs longer than 80 feet, additional expansion fittings every 400 feet	One expansion fitting in runs longer than 40 feet, additional expansion fittings every 200 feet
PVC	One expansion fitting in runs longer than 20 feet, additional expansion fittings every 100 feet	One expansion fitting in runs longer than 10 feet, additional expansion fittings every 50 feet

5. Flexible Connections: Use maximum of 6 feet of flexible metal conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement and for all motors. Use Liquidtight flexible metal conduit in wet or damp locations. Install ground conductor across flexible connections.
6. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling.

E. Conduit Bends:
   1. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
   2. Make bends and offsets so the inside diameter is not reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.
   3. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one-shot bender when field-fabricated elbows are required for bends in metal conduit larger than 2 inch size.
   4. Stub-Up Connections: Use type of conduit described for stub-ups from slab. Extend conduit through concrete floor for connection to freestanding equipment to a distance 6-inches above the floor. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

3.03 WIREWAY INSTALLATION

A. Wireway shall be securely fastened to walls using steel channels. Mount plumb and level.

B. Raintight wireways may only be installed in horizontal orientations.

3.04 POWER POLES

A. Mount straight and anchor to building structure above the ceiling line.

B. Provide mounting hardware, entrance end fitting and ceiling trim plate.

3.05 COMMUNICATIONS RACEWAY INSTALLATION REQUIREMENTS

A. General:
1. These guidelines are intended to supplement the requirements listed in other portions of this specifications section.
2. Minimum raceway size shall be as necessary to comply with fill ratio of referenced standards, but in no case less than 1 inch.
3. Provide specified pull wires in all cabling pathways.
4. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end.
5. Ground and bond all systems in accordance with the NEC and ANSI/TIA/EIA 607.
6. All installation material and practices shall fully comply with NFPA 70 “National Electrical Code” and ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces (BICSI).
7. Coordinate work with the building structural systems and electrical installation.
8. All work shall fully comply with these Specifications and related Drawings and all manufacturers’ recommended installation practices.
9. Do not install conduit in concrete slab.
10. There shall not be more than the equivalent of 180 degrees of bends in any single run of conduit between adequately sized pull.
11. Conduits entering a Telecommunications room below the finished ceiling shall be extended a minimum of 4-inches below the ceiling, and shall be routed as tight to the adjacent wall as possible.
12. Conduits entering a Telecommunications room through a wall shall extend 15 inches into the room and kept a minimum of 8 feet above finished floor.
13. Conduit bends:
    a. Bends shall be made so that the conduit will not be flattened or kinked and the internal diameter of the conduit will not be reduced.
    b. The radius of the curve of the inner edge of any bend shall not be less than as indicated by the National Electrical Code and ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces.
    c. In no case shall any conduit be bent or any fabricated elbow be applied to less than the allowable bending radius as specified by the cable manufacturer of the installed conductor.
    d. When necessary to make field bends, use tools designed for conduit bending. Heating of metallic conduit to facilitate bending is not permitted.
14. A conduit run shall not be longer than 100 feet between pull boxes for conduit runs inside a building.
15. Do not cut, burn or drill any structural member to mount electrical equipment or to facilitate tray or conduit installations without having previously received approval, in writing, from the Architect/Engineer/Consultant.
16. Mount all conduit a minimum of 6 inches above any accessible type ceiling.
17. Maintain conduit runs at least 6 inches from insulate pipes, steam lines or any other hot pipes they pass. Where the lines are not insulated, the clearances shall be increased until the temperature of the conduit, with no live conductors enclosed, does not rise above the ambient temperature of the installation area.

B. Communications Pathway Separation Requirements:
1. Provide separation of communications pathways to minimize the effects of electromagnetic interference (EMI) by installing pathways in the following manner:
    a. Provide a minimum of 37 inches separation from electrical motors and transformers and communications pathways.

b. When power lines or cables of different signal conditions must intersect, crossing shall be made at 90 degree angle, with proper separation as outlined above.

C. Open Top Cable Supports (J-Hooks):
1. Install J-hook pathway, supporting at least every 5 feet, as straight as possible parallel and/or perpendicular to building structure.
2. Shall be mounted to building structure or suspended by threaded rod from the deck above approximately 12 inches above suspended ceiling.
3. Attachment of J-hooks must be to building structure directly or utilize a minimum of 1/4 inch all-thread rod anchored into deck above.
4. Bundle cables with Velcro cable straps per TIA 596C and at each directional change.
5. Under no condition shall there be more than 12 inches of vertical cable sag between supports.
6. Cinch-tight cable ties are prohibited for all low voltage cabling support.
7. Cable routes of less than ten 4 pair UTP (or equivalent weight) may be supported with bridal rings at maximum 5 feet-0 inch intervals.
8. During installation of cables thru open top cable supports, pulling tension of cables shall not exceed 25 lbs.

3.06 SEISMIC REQUIREMENTS

A. Whenever Specification Section 13 05 41 "Seismic Restraints” is included in these specifications, the following is also required for those life safeties, emergency, fire alarms, etc., conduits that are defined therein. Details on the drawings, when shown, are intended to clarify or supplement these requirements:
1. All expansion joints shall be considered seismic joints that can cause movement in any direction during a seismic event. Conventional expansion fittings are not adequate for this condition.
2. For exposed conduit runs or runs in hung ceilings, provide a length of flexible metal conduit across the joint that will allow 2 inches of conduit movement in any direction. Length of the flexible section shall not exceed 6 feet.
3. For Slabs on Grade: Do not install any conduit through the joint in this slab. Routing underground beneath the joint is permitted only for conduit routed from a point in the building to a point beyond the perimeter of the building.

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.08 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.09 CLEANING

A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches and abrasions.

3.10 MARKING AND IDENTIFICATION

A. Mark and identify conduits in accordance with Section 26 05 53 “Identification for Electrical Systems.”

B. Mark and identify communications conduits in accordance with Section 27 05 53 “Identification for Communications Systems.”

3.11 RECORD DOCUMENTS

A. Accurately record actual routing of all feeder and sub-feeder conduits regardless of size and branch circuits conduits larger than 2-inches.

END OF SECTION

SECTION 26 05 34
BOXES, CABINETS, AND ENCLOSURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes boxes, cabinets and enclosures for electrical wiring.

1.03 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.04 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. Comply with the following standards:
   1. NECA "Standard of Installation."
   2. NEMA OS 1: Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
   3. NEMA OS 2: Non-Metallic Outlet Boxes, Device Boxes, Covers and Box Supports.
   4. NEMA FB 1: Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.
   5. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum).

PART 2 - PRODUCTS

2.01 OUTLET BOXES

A. General: Outlet boxes shall be constructed in accordance with National Electrical Code Article 314. Outlet boxes shall be sized for the volume required by the National Electrical Code, but in no case shall they be less than 1-1/2 inches deep.

B. Sheet Metal Boxes: Comply with NEMA OS 1, galvanized steel.

C. Nonmetallic Outlet Boxes: Comply with NEMA OS 2.

D. Cast Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, type FD with gasketed cover and threaded hubs.

E. Boxes for receptacle, telephone and data outlets shall be 4-11/16 inches square by 2-1/8 inches deep and shall be provided with extension rings. Furnish outlet boxes with fixture studs where required.

F. Boxes for switches or local light control shall be 4 inches square by 1-1/2 inches deep and shall be provided with raised cover to fit flush with finished wall line. Provide single box for multiple-ganged devices with single coverplate, sized for the quantity of devices to be installed.

G. Provide 4-inch octagonal and square outlet boxes for all exposed conduit work with fixture extension pan or deep fixture canopy to enclose the outlet box.

H. Boxes for recessed light fixtures shall be 4-inch octagonal or square according to fixture hardware requirements, minimum 1-1/2 inches deep complete with blank cover.

I. Provide corrosion-resistant steel knockout closures for unused openings.

2.02 FLOOR BOXES

A. Metal Floor Boxes: Cast metal, fully adjustable, rectangular.

2.03 JUNCTION AND PULL BOXES

A. Small Sheet Metal Pull and Junction Boxes: Comply with NEMA OS 1, galvanized steel. Flush-mounted boxes shall have an overlapping cover.

B. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1, galvanized or cast iron with gasketed cover.

C. Covers: Covers shall be the same material as the box. Covers shall be on the largest access side of the box, unless otherwise indicated.
   1. Less than 12 inches in any dimension: Screw-on cover.
   2. Greater than 12 inches in any dimension: Hinged cover.

D. Hinged-Cover Enclosures: Comply with NEMA 250, Type 1 with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2.04 CABINETS AND ENCLOSURES

A. Comply with NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.

B. Provide metal barriers to separate wiring of different systems and voltage.

C. Hinged Cover: Hinged door in front cover with flush latch and concealed hinge.

D. Where lockable cabinets are provided, key latch to match panelboards.

E. Provide accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.01 BOX AND CABINET INSTALLATION

A. General Installation Requirements:
   1. Electrical boxes are shown on drawings in approximate locations unless dimensioned. The Engineer or Architect shall be allowed to adjust the location of boxes up to 10 feet in any direction without additional cost to the project. This is intended for boxes for receptacles and switches and other wiring devices.
   2. Provide boxes as shown and for splices, taps, wire pulling, equipment and fixture connections and where required by applicable codes and installation practices.
   3. Locate boxes to maintain headroom and present a neat appearance. Locate to allow proper access. Provide access doors for boxes located above inaccessible ceilings.
   4. Provide knockout closures to cap unused knockout holes where blanks have been removed.
   5. Support all boxes, cabinets and enclosures rigidly and independently of conduit except where specifically allowed by the National Electrical Code. Use supports suitable for the purpose.
   6. Boxes located outdoors above ground shall be raintight and gasketed cast aluminum.
   7. Provide covers for all boxes.
   8. Do not install boxes back-to-back in same wall. Provide at least 6 inch separation or greater where required by the building code. In hollow fire walls, maintain minimum 24 inch horizontal separation between outlets on opposite sides. As an alternate to the 24 inch separation, the use of listed putty pads or other listed materials and methods approved by the Authority Having Jurisdiction are acceptable.

B. Floor Box Installation:
   1. Metal Floor Boxes: Set level and flush with finished floor surface.
   2. Nonmetallic Floor Boxes: Set level and trim after installation to fit flush with finished floor surface.

C. Outlet Box Installation:

1. All devices (receptacles, switches, occupancy sensors, fire alarm devices, low voltage devices, telephone jacks, data jacks, etc., and any other device) furnished under this project shall be mounted on or in an outlet box regardless of whether or not the associated system wiring is in conduit, unless otherwise noted.
2. Flush-mount outlet boxes in finished areas. Outlets in mechanical rooms, electrical rooms, and the above removable ceilings may be surface-mounted.
3. Use multiple gang boxes where more than one device is mounted together. Provide barriers to separate different voltage systems.
4. For outlets mounted above counters, benches, or backsplashes, coordinate location and mounting heights with architectural details. Install with bottom of box minimum 6 inch above backsplash.
5. Align wall-mounted outlet boxes for switches, thermostats and similar devices.
6. Adjust outlet mounting height and horizontal location to agree with required location for equipment served as may be shown on installation instructions or shop drawing for the equipment.
7. Position outlets to locate luminaires as shown on reflected ceiling drawings. For recessed boxes in finished areas, secure to interior wall and partition studs; allow for surface finish thickness.
8. Ensure that thermal insulation will be in place behind outlet boxes before installing them in insulated walls. Do not damage insulation.
9. Special care shall be taken to set all flush boxes square and true with the building finish. The edge of the cover shall meet the building finish or be no greater than 1/8 inch back from the finish surface. All wall outlets shall be rigidly secured to the stud system, using adjustable supports where necessary, to prevent all box movement.
10. Do not set boxes back further than required by Code. Coordinate with building finishes. Do not install any box so that the device pushes back into the wall when pushed. All boxes are to be set so that the device yoke will securely bear upon the box or wall finish. Where the sheetrock contractor cuts an opening too big for this to be achieved, install a fitting such as Caddy # RLC.
11. Installation within Masonry walls:
    a. Adjust position of outlets in finished masonry walls to suit masonry course lines where possible. Do not, however, violate maximum heights defined by accessibility codes such as ADA.
        1) Coordinate cutting in of walls to achieve neat openings for boxes. Locate boxes in walls so that only the corner need be cut from masonry units where possible.
        2) Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
12. Outlet Box Application: Unless otherwise noted, outlet boxes shall be installed as follows:
    a. Galvanized Steel Box Installation Locations:
        1) Concealed interior locations.
        2) Exposed interior locations above 7 feet-0 inches of finished floor.
        3) Kitchen and laundry rooms, when recessed.
    b. Cast Box Installation Locations:
        1) Exterior locations.
        2) Exposed interior locations within 7 feet-0 inches of finished floor.
        3) Wet or damp locations.
        4) Direct contact with earth or concrete slabs on grade.
        5) Kitchen and laundry rooms, when exposed.

D. Pull and Junction Boxes:
    1. Locate above accessible ceilings or in unfinished areas.

2. Locate pull or junction boxes to limit conduit runs to no more than 150 linear feet of four (4) 90 degree bends between pulling points. For telephone/ data limit bends to no more than three (3) 90 degree bends to pulling points.

E. Cabinets and Enclosures:
   1. Install hinged cover enclosures and cabinets plumb. At a minimum, support at each corner.
   2. Provide knockout closures to cap unused knockout holes where blanks have been removed.

3.02 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.03 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

3.04 CLEANING

A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

3.05 MARKING AND IDENTIFICATION

A. Mark and identify boxes, cabinets and enclosures in accordance with Section 26 05 53 “Identification for Electrical Systems.”

END OF SECTION

SECTION 26 05 36
CABLE TRAYS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Cable trays.
   2. Cable tray accessories.

1.03 SUBMITTALS

A. Product Data: Include for each tray type, dimensions, support points, clamps, hangers, connectors, fittings, expansion joint assemblies, accessories and finishes.

B. Shop Drawings: For each type of cable tray.
   1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
   2. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
      a. Design Calculations: Calculate requirements for selecting seismic restraints.
      b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

C. Coordination Drawings: The contractor shall be responsible for coordinating the cable tray layout with all building components (ducts, pipes, fire protection, columns, beams, walls, etc.). Make changes in cable tray direction and elevation as required.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. 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.

C. Comply with the following codes and standards:
   1. NFPA 70.
   2. ASTM B 633.
   3. ASTM F 593.
   4. ASTM F 594.
   5. ASTM F 1136.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Cable tray shall be stored in a well-ventilated, dry location. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 degrees F, ambient; 180 degrees F, material surfaces.

2.02 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
   1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the drawings for specific requirements for types, materials, sizes, and configurations in specific locations.

C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:
   1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 2.
   2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
   3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.03 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Legrand Cablofil.
   2. PW Industries.
   3. Cooper B-Line, Inc.
   4. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.
   5. MONO-SYSTEMS, Inc.
   6. MPHusky.
   7. Chalfont Manufacturing Company.
   8. Thomas & Betts.

2.04 LADDER-TYPE CABLE TRAYS

A. Description:
   1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
   2. Rung Spacing:9 inches on center.
   3. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
   4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
   5. No portion of the rungs shall protrude below the bottom plane of side rails.
   6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
   7. Minimum Usable Load Depth: 6 inches.
   8. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
   9. Width: 24 inches unless otherwise indicated on Drawings.
   10. Fitting Minimum Radius: 36 inches.
   11. Class Designation: Comply with NEMA VE 1, Class 12C.
   12. Splicing Assemblies: Bolted type using serrated flange locknuts.
   13. Hardware and Fasteners: Steel, zinc plated.
   14. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

B. Materials and Finishes:
   1. Steel:
      a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.

b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
d. Finish: Electrogalvanized before fabrication.
1) Standard: Comply with ASTM B 633.
2) Hardware: Galvanized, ASTM B 633.

C. Cable Tray Accessories:
1. Accessories: Provide all supporting, hanging, tee, cross, level change, reducing, drop outs, and miscellaneous hardware as required for a complete and functioning installation to manufacturer's recommendations.
2. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
3. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

D. Cable Drop-outs ("Waterfalls"):
1. Shall mount securely to ladder rack rails and shall maintain minimum bend radius on all cables entering or exiting the Ladder Rack.

E. Cable Fencing:
1. Minimum 7 inches high, at 3 feet-0 inches on center for entire route of cable tray.

2.05 WELDED WIRE MESH CABLE TRAYS

A. Tray: Continuous, rigid, welded steel wire mesh cable tray with continuous top wire safe edge with T-weld.

B. Wire mesh shall be welded at all intersections.

C. Size: Depth, loading depth, and width to be as shown on drawings. Mesh to be 2 inch x 4 inch nominal.

D. Provide grounding clip for continuous grounding of tray.

E. Load Span Criteria: Install and support cable management system in accordance with span load criteria of L/240.

F. Material and Finishes:
1. Steel:
a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
d. Finish: Electrogalvanized before fabrication.
1) Standard: Comply with ASTM B 633.
2) Hardware: Galvanized, ASTM B 633.

G. Cable Tray Accessories:
1. Accessories: Provide all supporting, hanging, tee, cross, level change, reducing, drop outs, and miscellaneous hardware as required for a complete and functioning installation to manufacturer's recommendations.
2. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
3. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.06 WARNING SIGNS

A. Provide manufacturer's standard, permanent, legible warning label indicating the following:

WARNING! DO NOT USE AS A WALKWAY, LADDER, OR SUPPORT FOR PERSONNEL. TO BE USED ONLY AS MECHANICAL SUPPORT FOR CABLES AND TUBING!

B. Label shall also indicate cable tray NEMA load class. Label shall be a maximum of 10’ on center.

C. Cable trays containing conductors rated over 600 volts shall have a label with the wording “DANGER-HIGH VOLTAGE-KEEP AWAY.”

D. Cable trays containing service entrance conductors shall be labeled with “CABLE TRAY CONTAINS SERVICE-ENTRANCE CONDUCTORS.”

PART 3 - EXECUTION

3.01 INSTALLATION

A. General Installation Requirements

1. Refer to the drawings for specific cable tray routings, sizes, types, and accessories to be installed in specified locations.
2. Cable tray shall be installed parallel and perpendicular to building structural and wall lines.
3. Install cable tray in accessible locations only. Where portions of a cable tray route will be inaccessible, provide conduit sleeves for the duration of the inaccessible route. Conduit sleeves shall have cable capacity equal to or greater than the capacity of the cable tray being supplemented.
4. Install in conformance with NEMA VE 2 requirements and in accordance with manufacturer's instructions.
5. Support cable tray at each connection point, at the end of each run, and at other points to maintain spacing between supports of 8 feet maximum.
6. Tray shall be electrically continuous from source to termination and shall not change elevation, direction or otherwise expose cables to travel without support.
7. All splices of tray shall be provided with splice washers, bars or springs as recommended by the manufacturer.
8. Provide bonding continuity between cable tray sections, fittings and conduit terminations in accordance with manufacturer's instructions.
9. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.
10. Remove burrs and sharp edges from cable trays.
11. Seal penetrations through fire and smoke barriers.
12. Install capped sleeves for future cables through firestop sealed cable tray penetrations of fire and smoke barriers as shown on drawings.
13. Install cable trays with sufficient space to permit access for installing cables. Install tray bottom within 8 inches of access ceiling paneling for ease of access. Adjust mounting height only momentarily for field coordination with other trades and systems as required.
14. Provide separation of cables of different systems, such as power, telecommunications, fire alarm system, security systems and audio or visual systems. Install barriers between power and low voltage cables.
15. Provide seismic bracing of cable tray in accordance with Section 13 05 41 “Seismic Restraints.”
16. Install cable trays according to NEMA VE 2.
17. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
18. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
19. Fasten cable tray supports to building structure and install seismic restraints.

20. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."
21. Place supports so that spans do not exceed maximum spans and provide clearances as required. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
22. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
23. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
24. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
25. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
26. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
27. The contractor shall be required to make changes in direction and elevation in order to provide a continuous cable tray routing as indicated on the construction documents and engineer approved coordination drawings. Changes in direction and elevation shall be made using manufacturer's recommended fittings.
28. Make cable tray connections using manufacturer's recommended fittings.
29. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 8413 "Penetration Firestopping."
30. Install cable trays with enough workspace to permit access for installing cables.
31. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.02 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.03 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

3.04 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

C. Install cables only when cable tray installation has been completed and inspected.

D. Ground cable trays according to manufacturer's written instructions.

E. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

3.05 WIRE MESH TYPE CABLE TRAY

A. Cut standard straight sections to length in field.

B. Tray shall be field cut using the manufacturer's approved cutting device and methods. Cutting device shall be an offset blade bolt cutter. The use of standard bolt cutters is strictly prohibited.

C. Bends in tray shall be accomplished by utilizing manufacturer's cutting guides.

3.06 REQUIREMENTS FOR TELECOMMUNICATIONS SPACES

A. This section is designed to provide the contractor/vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.

B. Telecommunications Room and Communications Space Requirements:
   1. Provide ladder rack for all telecommunications cabling in the TR(s) as shown on the drawings.
      a. Fill capacity (as designated by the manufacturer) shall not be exceeded.
      b. Utilize properly sized supports with adequate strength to exceed the maximum recommended weight capacity.
   2. Ladder rack minimum requirements are as shown on the drawings.
      a. Provide and secure ladder rack for cable support Technology Systems.
      b. Technology systems include but are not limited to:
         1) Voice/Telephone Systems.
         2) Network/Data Systems.
         3) Teleconferencing Systems.

C. Ladder Rack Installation:
   1. Horizontally mounted:
      a. Ladder rack shall mount approximately 6 inches above equipment racks, cabinets or enclosures or as indicated on the drawings.
      b. Rack mounted with a side along a backboard; mount with wall brackets; utilize threaded rod and manufacturer's bracket kits for suspension of all remaining ladder rack sections.
      c. Provide support for the ladder rack at a minimum of 5 feet on center and within 2 feet of each end of all splices, tees, elbows, bends, intersections, and transitions.
         1) Support with threaded rod and U-channel supports systems: 12 inch width, 1/2 inch ATR; 24 inch width, 5/8 inch ATR.
         2) Rod lengths over 6 feet will require a "Rod Stiffener" installation.
            a) A section of U-Channel stock is placed around the rod and stiffener clamp assemblies used to clamp to rod. Place clamps a minimum of 6 inches from the top and bottom of the rod and every 18 inches in between.
      d. Ground and bond the system in accordance with the NEC and ANSI/TIA/EIA 607.
      e. Provide side posts at 3 feet on center to both sides of the rack lengths.
      f. Provide end caps as specified.
      g. Install "waterfall" type protection for cable exit downward between rungs.
      h. Paint fittings as required to maintain aesthetic integrity of the installation.

3.07 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

3.08 PROTECTION

A. Protect installed cable trays and cables.
   1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
   2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
   3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Conduit, ducts, and duct accessories for direct-buried duct banks, and single duct runs.
   2. Handholes and pull boxes.

1.03 DEFINITION

A. RNC: Rigid nonmetallic conduit.

B. RMC: Rigid metallic conduit

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Duct-bank materials, including separators and miscellaneous components.
   2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings and solvent cement.
   3. Warning tape.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work and accessories, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Reinforcement details.
   3. Frame and cover design.
   4. Dimensioned locations of cable rack inserts, pulling-in and lifting irons and sumps.
   5. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections and elevations, and fabrication and installation details, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Cover design.
   3. Dimensioned locations of cable rack inserts and pulling-in and lifting irons.

D. Field test reports indicating and interpreting test results relative to compliance with performance requirements of "Field Quality Control" Article in Part 3 of this Section.

E. Record Documents: Show dimensioned locations of underground ducts and handholes.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firm experienced in manufacturing underground precast concrete utility structures of types and sizes required and similar to those indicated for this Project. Firm must have a record of successful in-service performance.

B. Comply with NFPA 70 "National Electrical Code" and ANSI C2 "National Electrical Safety Code" for components and installation.

C. Coordinate layout and installation of ducts and handholes with final arrangement of other utilities as determined in the field.

D. Coordinate elevations of duct and duct bank entrances into handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions.

Revise locations and elevations from those indicated as required to suit field conditions and ensure duct runs drain to handholes, and as approved by the Engineer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store all underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

PART 2 - PRODUCTS

2.01 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide specified products by one of the following:
   1. Underground Precast Concrete Utility Structures (handholes, pull boxes):
      a. Precast Division; Carder Concrete Products.
      b. Champion Pre-cast Incorporated.
      c. Elmhurst-Chicago Stone Co.
      d. New Basis.
      e. Riverton Concrete Products.
   2. Nonmetallic Ducts:
      a. CANTEX, Inc.
      b. Certainteed Corp, Pipe & Plastics Group.
      c. Allied Tube & Conduit.
      d. Carlon.
   3. Underground Non-metallic Boxes (handholes, pull boxes):
      a. Associated Plastics.
      b. Carlon.
      c. Quazite.
      d. Synertech.

B. Conduit and Duct:
      a. NEMA TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
      b. PVC Conduit and Tubing Fittings: NEMA TC 3.

C. Manufactured Bends: Not less than 36-inch radius.

2.02 METAL CONDUIT AND TUBING

A. Rigid Steel (Metallic) Conduit:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. LTV Steel Tubular Products Company.
      c. O-Z Gedney.
      d. Wheatland Tube Company.
   2. Description: Conduit to be seamless, hot dipped galvanized rigid steel. Threads to be cut and ends chamfered prior to galvanizing. Galvanizing to provide zinc coating fused to inside and outside walls of conduit. Provide an enamel lubricating coating on the inside of the conduit. Conduit to conform to ANSI C80.1 and listed and labeled under UL 6.
   3. Fittings and Conduit Bodies: NEMA FB 1, single piece threaded, cadmium plated malleable iron.

4. Joint Compound: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.03 PRECAST CONCRETE HANDHOLES AND PULL BOXES

A. Comply with ASTM C 858 for design and manufacturing processes.

B. Hardware shall be stainless steel.

C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.
   1. Frame and Cover: Weatherproof cast-iron frame with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing stainless steel bolts.
   2. Frame and Cover: Weatherproof steel frame with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing stainless steel bolts.
   3. Frame and Cover: Weatherproof steel frame with hinged steel access door assembly with tamper-resistant, captive, cover-securing stainless steel bolts.
      a. Cover Hinges: Concealed, with hold-open ratchet assembly.
      b. Cover Handle: Recessed.
   4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing stainless steel bolts.
      a. Cover Hinges: Concealed, with hold-open ratchet assembly.
      b. Cover Handle: Recessed.
   5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   6. Cover Legend: Molded lettering, "ELECTRIC." "TELEPHONE." As indicated for each service.
   7. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
   8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
      a. Extension shall provide increased depth of 6 inches.
      b. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.
   9. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
      a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
      b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
      c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
   10. Cast end-bell or duct-terminating fitting in wall for each entering duct:
      a. Type and size shall match fittings to duct or conduit to be terminated.
      b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
   11. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.04 HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.
   1. Color: Gray.

2. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering:
   a. "ELECTRIC." "TELEPHONE." As indicated for each service.
   b. Tier level number, indicating that the unit complies with the structural load test for that tier according to SCTE 77.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, retained to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two. Handholes and pull boxes shall comply with the requirements of SCTE 7 Tier 8 loading.

C. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete, complying with SCTE 77 Tier 8 loading.

2.05 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Non-concrete Handhole and Pull Box Prototype Test: Test prototypes of pull boxes for compliance with SCTE 77. Strength tests shall be for specified Tier ratings of products supplied.

PART 3 - EXECUTION

3.01 CORROSION PROTECTION

A. Aluminum shall not be installed in contact with earth or concrete.

3.02 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables over 600 V: RNC, NEMA TC 2 Schedule 40-PVC, unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA TC2 Schedule 40-PVC, in direct-buried duct bank unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: RNC, NEMA TC 2 Schedule 40-PVC, in direct-buried duct bank unless otherwise indicated.

D. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, Schedule 40-PVC, in direct-buried duct bank unless otherwise indicated.

E. Underground Ducts Crossing Driveways and Roadways: RNC, NEMA Schedule 40-PVC, encased in reinforced concrete.

3.03 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
   1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete.

2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf "Light-Duty" vertical loading.

3.04 EXAMINATION

A. Examine site to receive ducts for compliance with installation tolerances and other conditions affecting performance of the underground ducts. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.05 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoil, fertilizer, lime, seed, sod, sprig and mulch. Comply with Division 32 Sections "Turf and Grasses" and "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 02 Section "Cutting and Patching."

3.06 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of three feet both horizontally and vertically at other locations. Use larger sweeps when called out on documents, or otherwise required. RTRC (fiberglass) long sweep elbows may be used to reduce the coefficient of friction and elbow burn-through.

C. Joints: Make joints in ducts and fittings watertight according to manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.

D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches on-center for 5-inch ducts, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10 ft. from the end bell without reducing duct line slope and without forming a trap in the line.
   2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to handhole.
   3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 ft. outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified below:
   1. Direct-Buried, Non-encased Duct Entering Non-waterproofed Walls: Install a Schedule 40 galvanized-steel pipe sleeve for each duct. Caulk space between conduit and sleeve with duct-sealing compound on both sides for moisture-tight seal.

2. Waterproofed Wall and Floor Entrances: Install a watertight entrance-sealing device with the sealing gland assembly on the inside. Anchor device into masonry construction with one or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.
3. Separation Between Direct-Buried, Non-encased Ducts: 3 inches minimum for like services, and 6 inches minimum between power and signal ducts.

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling Cord: Install 100-lbf test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators coordinated with duct size and required duct spacing, and install according to the following:
1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between terminations in one continuous operation.
   a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
   b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.
3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
7. Depth: Except as otherwise indicated on drawings, install top of duct bank at least 24 inches below finished grade in non-traffic areas and at least 30 inches below finished grade in vehicular traffic areas. Bottom of duct bank shall not be less than 30 inches below grade to eliminate frost heave.
8. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
9. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct

bank. Provide an additional warning tape for each 12 inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

10. Apply red concrete dye to the surface of the concrete immediately after the pour.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank.
4. Install backfill as specified in Division 31 Section "Earth Moving."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
10. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12 inch increment of duct bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.07 INSTALLATION OF CONCRETE HANDHOLES AND PULL BOXES

A. Precast Concrete Handhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Install handholes with bottom below the frost line unless otherwise noted.
2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Field-Installed Bolting Anchors in Concrete Handholes: Do not drill deeper than 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.08 INSTALLATION OF HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use pull box extension if required to match depths of ducts and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a Level 6 inch thick bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: Set so cover surface will be flush with finished grade.

D. Install handholes and pull boxes with bottom below the frost line.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms and insulators, as required for installation and support of cables and conductors and as indicated. Retain arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
   2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel 1/4 inch smaller in diameter than internal diameter of ducts. If obstructions are indicated, remove obstructions and retest.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Identification for underground systems.
2. Identification for raceways.
3. Identification for wires, cables and conductors.
4. Warning labels and signs.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

1.03 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.04 QUALITY ASSURANCE

A. Comply with the following standards:
1. ANSI A13.1 and IEEE C2.
2. NFPA 70.
3. 29 CFR 1910.144 and 29 CFR 1910.145.
4. ANSI Z535.4 for safety signs and labels.

B. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.05 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

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

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

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Electromark - Wolcott, New York.
2. Ideal Industries, Inc.
3. 3M.
4. Panduit Corp.
5. Seton Name Plate Co.
6. Thomas & Betts.

7. W. H. Brady, Co. - Signmark Division - Milwaukee, Wisconsin.

2.02 ELECTRICAL IDENTIFICATION PRODUCTS

A. Self-Adhesive Vinyl Labels (Raceways and Boxes): Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

B. Self-Adhesive Vinyl Tape for Banding (Raceway, Wire and Cable): Colored, heavy duty, waterproof, fade resistant; 2 inches wide.

C. Self-Adhesive Tape Markers (Wire and Cable): Vinyl or vinyl-cloth, self-adhesive, wraparound, cable and conductor markers with preprinted numbers and letters.

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

E. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

F. Snap-Around, Color-Coding Bands (Raceways and Cables): Slit, pre-tensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

G. Colored Adhesive Marking Tape (Raceways, Wires, and Cables): Self-adhesive plastic coated cloth tape similar to Brady 441XX or 442XX series.

H. Conductor Identification Products:
   1. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
   2. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

I. Floor Marking Tape:
   1. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

J. Underground Line Warning Tape:
   1. Underground Line Marking Tape: Permanent, bright-colored, corrosion-resistant, continuous-printed, plastic tape compounded for direct-burial service not less than 6 inches wide by 4 mils thick. Printed legend shall be indicative of general type of underground line below. Tape shall have integral metallic facing or metallic core to allow locating buried tape with electronic detection equipment. Provide marking tape similar to Thomas & Betts NAF series.

2.03 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application with 1/4-inch grommets in corners for mounting, nominal 7 by 10 inches in size unless noted otherwise.

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. Provide 1/4-inch grommets in corners for mounting, nominal 10 by 14 inches in size unless noted otherwise.

E. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field-printed legends to suit the application. Orange background, except as otherwise indicated, with eyelet for fastener.

F. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in black letters on white face and punched for mechanical fasteners.

2.04 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Overlay shall provide a weatherproof and UV-resistant seal for label. Labels shall be at least 2-1/4 inches high. Where space does not permit this label size, smaller stock and lettering is permitted.

B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with lettering and background colors as indicated. Labels shall be at least 2-1/4 inches high. Where space does not permit this label size, smaller stock and lettering is permitted.

C. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Labels shall be at least 2-1/4 inches high. Where space does not permit this label size, smaller stock and lettering is permitted.

2.05 CABLE TIES

A. Cable Ties: Fungus-inert, self-extinguishing, nylon one-piece, self-locking cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a minimum temperature range from minus 50 degrees F to 350 degrees F. Provide ties in specified colors when used for color-coding.

B. Identification Cable Ties: Same as "Cable Ties" above, except with integral tab of suitable size for marking requirements.

2.06 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior). Comply with maximum volatile organic compound levels imposed within Division 09.

B. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Increase size of labels and letters to those appropriate for viewing from the floor for elevated components.

C. Lettering and Graphics: Coordinate names, abbreviations, colors and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering and colors as required by code.

D. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.

E. Clean and degrease surfaces prior to applying identification products. Apply identification to surfaces that require finish after finish work is completed. Utilize primer for metal surfaces, heavy-duty acrylic resin block filler for concrete masonry, and clear alkali-resistant alkyd binder-type sealer for concrete surfaces.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

I. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

J. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.02 LABEL COLOR CODE LEGEND

A. Provide the following color-coding scheme for each label based on the power system it is identifying:
   1. Normal Power: Black letters on white background.
   2. Emergency Branch: White letters on red background.

3.03 UNDERGROUND SERVICE IDENTIFICATION

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch-wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication and control wiring and optical fiber cable.

C. Underground Electrical Line Identification: During trench backfilling, for exterior underground power, signal and communications lines, install continuous underground line marking tape located directly above each respective line at 6 to 8 inches below finished grade.

3.04 RACEWAY IDENTIFICATION

A. Where conduits leave a switchboard, panelboard, motor control center, etc., identification shall be provided on each conduit indicating the load being served.

B. Contractor shall be responsible for providing the Owner with laminated, colored, typewritten legends indicating the identification color scheme. At a minimum, these legends should be installed in the main electrical room and branch electrical closets. Provide two additional legends to the Owner to use at their discretion.

C. Identification of Raceways with Labeling:
   1. Raceway Labeling: Provide labeling on conduits indicating electrical distribution system contained within (e.g. Normal, Life Safety, etc.) and operating voltage level. Label size shall be as follows:

Nominal EMT conduit size	Nominal RGS conduit size	Length of color background on label	Height of letters
up to 1 inch	up to 3/4 inch	8 inches	1/2 inch
1.25 to 1.5 inches	1 to 1.5 inches	8 inches	3/4 inch
2 to 5 inches	2 to 5 inches	12 inches	1.25 inches
6 inches	6 inches	24 inches	2.5 inches

2. Raceways carrying circuits over 600V: Provide label with 3-inch high letters on 20-inch centers to read as follows: "DANGER CONCEALED HIGH VOLTAGE WIRING."

3.05 BOX IDENTIFICATION

A. Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage:
   1. Normal Power.
   2. Emergency Power.

B. At each junction, pull and connection box, identify the following: with self-adhesive vinyl labels. Identification of these boxes shall be located on the inside of cover if located in finished spaces:
   1. Power and lighting circuits: Indicate system voltage and identify contained circuits and panelboard serving load (e.g., “120V, PP1-1, 3, 5”).
   2. Other wiring: Indicate system type and wiring description (e.g., “FIRE ALARM NAC #2”).

C. Paint box covers to correspond with system types as follows:
   1. Fire Alarm: Red.

3.06 CIRCUIT IDENTIFICATION

A. Label conductors as follows:
   1. Multiple Power or Lighting Circuits in the Same Enclosure: Where multiple branch circuits are terminated or spliced in a box or enclosure, label each conductor with source and circuit number.
   2. Multiple Control Wiring and Communication/Signal Circuits in Same Enclosure: For control and communications signal/wiring, use wire/cable marking tape at terminations in wiring boxes, troughs and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tape.

3.07 CONDUCTOR COLOR CODING

A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, panelboards, manholes, handholes, switches, etc., use color-coding conductor tape to identify the phase.
   1. Color-Coding for Conductors rated 600 V or Less: Use colors listed below for all conductors.
      a. Color shall be factory-applied, or field-applied for sizes larger than No. 6 AWG, if Authorities Having Jurisdiction permit
         1) Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
      b. Colors for 208/120V Circuits:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.
         4) Neutral: White.
         5) Ground Bond: Green.

c. Colors for 480/277V Circuits:
   1) Phase A: Brown.
   2) Phase B: Orange.
   3) Phase C: Yellow.
   4) Neutral: Gray.
   5) Ground Bond: Green.

B. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control and signal connections.
   1. Identify conductors, cables and terminals in enclosures and at junctions, terminals and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

C. Open Cable Identification
   1. Low Voltage Cable (Less than 120V): Provide self-adhesive pre-printed vinyl tape markers at 20 foot intervals to identify all cables run exposed or located above the accessible ceilings. Indicate the associated system by using the following color coding schemes:
      a. Fire Alarm: Red lettering on white background.
      b. Temperature Controls: Blue lettering on white background.
      c. Security System: Black lettering on white background.
      d. Telephone System: White lettering on blue background.

3.08 RECEPTACLE IDENTIFICATION

A. Identification Material: Pre-printed, self-laminating vinyl labels, 3/16-inch font height. Utilize black lettering on clear background for normal power circuits and red lettering on a clear background for emergency power circuits.

B. Coverplates: Provide identification on all receptacle coverplates indicating the source panelboard and circuit number serving the device (e.g., PP1#1).

3.09 SIGNAGE

A. Install instructional sign in each electrical room including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

B. Apply warning, caution, and instruction signs and stencils as follows:
   1. Install warning, caution or operating instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install fiberglass signs or outdoor items.
   2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding or other emergency operations where required by NEC or where required to assure safe operation and maintenance.
   3. Arc Flash Hazard Warning: Provide signage on all electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures and motor control centers indicating arc flash hazard warning and advising appropriate PPE.

3.10 ELECTRICAL EQUIPMENT IDENTIFICATION

A. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, one-line diagram, schedules and the Operation and Maintenance Manual. Each section of a multiple-section equipment lineup shall be provided with its own identification label. Apply labels to disconnect switches and protection equipment, central or master units, control

panels, control stations, terminal cabinets and racks of each system. Systems include power, lighting, control, communication, signal, monitoring and alarm systems unless equipment is provided with its own identification.

B. Labeling Instructions:
   1. Indoor Equipment: Provide self-adhesive, engraved, laminated acrylic or melamine label.
   2. Outdoor Equipment: Provide engraved, laminated acrylic or melamine label.
   3. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
   4. Nameplate Data: Provide permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances and similar essential data. Locate nameplates in an accessible location.
   5. Service Disconnects: Provide permanent engraved sign with 2-1/4 inch high black lettering on white background clearly describing the location of all other service disconnecting means (including engine generator sources and central battery systems) when the building is served by more than one source of electrical power. Locate signs at each power source's disconnect means.
   6. Outdoor Electrical Equipment: Provide outdoor Pictogram type sign per above specifications, with the words "DANGER - HIGH VOLTAGE Hazardous Voltage. Will shock burn, or cause death. KEEP OUT." NEMA Mr. Ouch symbol shall be included. Install at all entrances to outdoor areas and every 20 feet along area fences, with at least one sign per side of fencing. Install on doors to equipment.
   7. Fusible Switches: Install fuse manufacturer-supplied labels inside the door of the fusible switch indicating the proper type and fuse required for replacement.
   8. Automatically Started Equipment: Provide adhesive label reading "DANGER - WARNING THIS MACHINE IS AUTOMATICALLY CONTROLLED. IT MAY START AT ANY TIME" on all motors, generators and other moving or hazardous equipment which is remotely or automatically operated. Sign to be similar to Brady Number 88191.

C. Specific Equipment Requirements:
   1. Power Distribution Equipment: Including, but not limited to switchgear, switchboards, distribution panelboards, branch panelboards and motor control centers.
      a. Identification label shall include the following:
         1) Equipment type and tag designation shown on the contract documents using 1/2 inch high bold lettering.
         2) Voltage and phase rating of the equipment using 1/4 inch high bold lettering.
         3) The name of the upstream equipment and location/room number it is located in using 1/4 inch high bold lettering.
         4) Rating and type of overcurrent protection device serving the equipment (e.g., “FED FROM 200A/3P CIRCUIT BREAKER”) using 1/4 inch high bold lettering.
      b. Example Identification Label:

DISTRIBUTION PANEL ‘DP1’
208Y/120V 3-Phase 4-Wire
Fed from Panel MP1; Room 200
Fed from 200A/3P Circuit Breaker

      c. A separate nameplate shall be provided at the service entrance equipment for all sources of power indicating the maximum available fault current and the date the fault current calculation was performed.
      d. Distribution panelboards and switchboards shall be provided with permanent labeling adjacent to each overcurrent protection device indicating the load being served and the location of the equipment.

e. A typewritten directory of circuits shall be provided at all branch panelboards. Provide explicit description and identification of items served by each individual switch and circuit breaker.

2. Transformers:
   a. Identification label shall include the following:
      1) Equipment type and tag designation shown on the contract documents in 1/2 inch high bold lettering.
      2) Voltage and phase rating of equipment using 1/4 inch high bold lettering.
      3) The name of the upstream equipment and location/room number it is located in using 1/4 inch high bold lettering.
      4) Rating and type of overcurrent protection device serving the equipment (e.g., “FED FROM 70A/3P CIRCUIT BREAKER”) using 1/4 inch high bold lettering.
   b. Example Identification Label:

TRANSFORMER ‘T1’
480Δ:208Y/120V 75kVA
Fed from Panel DP1; Room 200
Fed from 125A/3P Circuit Breaker

3. Control Equipment: Including but not limited to disconnect switches, starters, variable-speed controllers, contactors, motor control centers, pushbutton stations, etc.
   a. Identification label shall include the following:
      1) Equipment type and tag designation shown on the contract documents of the actual equipment served in 1/2 inch high bold lettering.
      2) Location of equipment being served in 1/4 inch high bold lettering. If the equipment being served by the control equipment is located in the same room, identify location as “THIS ROOM.”
      3) Voltage and phase rating of equipment in 1/4 inch high bold lettering.
      4) The name of the upstream equipment and location/room number it is located in using 1/4 inch high bold lettering.
   b. Example Identification Label:

AHU-6 Supply Fan ‘AHU-6S’
Located in Mechanical Room 001
480V 3-Phase, 3 Wire
Fed from Distribution Panel MHEQ; Room 200

4. Power Transfer Equipment.
   a. Identification label shall include the following:
      1) Equipment type and tag designation shown on the contract documents in 1/2 inch high bold lettering.
      2) The power branch the power transfer equipment serves (e.g., CRITICAL, LIFE SAFETY, EQUIPMENT, NORMAL) in 1/2 inch high bold lettering.
      3) Voltage, phase rating and pole quantity of equipment using 1/4 inch high bold lettering.
      4) The name of upstream equipment and location/room number it is located in using 1/4 inch high bold lettering. Differentiate upstream sources by indicating Normally Closed (NC) and Normally Open (NO). If the upstream equipment supplying power is located in the same room as the power transfer equipment, identify location as “THIS ROOM.”
      5) The name of the downstream equipment and location/room number it is located in using 1/4 inch high bold lettering. If the downstream equipment being served is located in the same room as the power transfer equipment, identify location as “THIS ROOM.”
   b. Example Identification Label:

AUTOMATIC TRANSFER SWITCH ‘ATS-C1’
CRITICAL POWER
480Y/277V 3-Phase, 4-Wire, 4-Pole
Upstream Source (NC): Fed from Panel ‘SB-1’; Room 200
Upstream Source (NO): Fed From Panel ‘SB-GP’; Room 201
Downstream: Feeds Distribution Panel ‘DP-C1’

END OF SECTION

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Countdown time switches.
   2. Exterior photocells.
   3. Occupancy sensors.
   4. Daylight sensors
   5. Lighting contactors.
   6. Emergency shunt relays.
   7. Room Scene Controllers.

B. Related Requirements:
   1. Section 26 27 26 "Wiring Devices" for wall-box dimmers, and manual light switches.

1.03 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

C. For products used in lieu of basis of design, submit a lighting plan clearly marked by manufacturer showing proper product, location and orientation of each sensor.

D. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Products supplied shall be from a single manufacturer that has been continuously involved in manufacturing of lighting controls for a minimum of five (5) years. Mixing of manufacturers shall not be allowed.

B. All components shall be U.L. listed, offer a five (5) year warranty and meet all state and local applicable code requirements.

C. All occupancy sensors shall be tested to NEMA WD 7-2011 Occupancy Motion Sensors Standard.

1.05 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including luminaires, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

PART 2 - PRODUCTS

2.01 MANUFACTURES: Basis of design is based on Wattstopper digital lighting management system in areas with scene controllers. Each of these areas shall be complete with room controller, sensors, power pack, wall controllers, low voltage wiring and daylight sensors. Outside lighting control shall include photocell, astronomical time clock, dimmer/relay panel and lighting control master controller.

A. Equals allowed by the following:
   1. Cooper Industries, Inc
   2. Acuity lighting controls

3. Leviton
4. Lutron

2.02 COUNTDOWN TIME SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide WattStopper TS400 or comparable product by one of the following:
   1. Cooper Industries, Inc.
   2. Hubbell Building Automation
   3. Leviton Manufacturing Co., Inc.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

C. Time switch shall be a completely self-contained control system that replaces the standard toggle switch. It shall have a ground wire and ground strap for safety. Switching mechanism shall be a latching air gap relay.

D. Zero Crossing Circuitry shall be used to increase the relay life, protect from the effects of inrush current, and increase the switch's longevity.

E. Time switch shall be compatible with all electronic ballasts, motor loads, compact fluorescent and inductive loads. Triac and other harmonic generating devices shall not be allowed.

F. Time switch shall operate at universal voltages of 100-300 VAC; 50/60 Hz.

G. Time-out period shall be adjustable in increments of 5 minutes from 5 minutes to 1 hour, and in increments of 15 minutes from 1 hour to 12 hours.

H. Time switch shall have the option for a beep warning that shall sound every five seconds once the time switch countdown reaches one minute.

2.03 EXTERIOR PHOTOCELLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Cooper Industries, Inc.
   2. Hubbell Building Automation.
   3. Intermatic, Inc.
   4. Leviton.

B. Description: Solid state, with SPST dry contacts rated, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
   3. Time Delay: Fifteen second minimum, to prevent false operation.
   4. Surge Protection: Metal-oxide varistor.
   5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.04 MANAGEMENT INTERFACE:

A. System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.

2.05 IRED NETWORKED WALL SWITCHES, DIMMERS, SCENE CONTROLLERS

A. Devices shall recess into single-gang or two gang switch box and fit a standard GFI opening.

B. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.

C. All switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.

D. Devices with mechanical pushbuttons shall provide tactile and LED user feedback.

E. Devices with mechanical pushbuttons shall be made available with custom button labeling.

F. Wall switches & dimmers shall support the following device options:

1. Number of control zones: 1, 2 or 4

2. Control Types Supported:

a. On/Off

b. On/Off/Dimming

c. On/Off/Dimming/Correlated Color Red, Green Blue Control for specific luminaire types.

2.06 WIRED NETWORKED DIGITAL KEY SWITCHES

A. Devices shall recess into single-gang switch box and fit a standard GFI opening.

B. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.

C. All switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.

D. Devices shall have LED user feedback to provide indication of on/off status of the programmed lights or scene, as well as indication of device power.

E. Digital key switches shall support the following device options:

1. Control Types Supported:

a. On/Off
b. On/Off/Dimming
c. Preset Level Scene Type

2.07 WIRED NETWORKED AUXILIARY INPUT / OUTPUT (I/O) DEVICES

A. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½" knockout.

B. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.

C. Output shall be programmable to support all standard sequence of operations supported by system.

2.08 WIRED NETWORKED OCCUPANCY AND PHOTOSENSORS

A. Occupancy sensors shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.

B. Sensors shall utilize Dual technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions.

C. System shall have ceiling, recessed & corner mounted sensors available, with multiple lens options available customized for specific applications.

D. Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.

E. All sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.

F. Sensor programming parameter shall be available and configurable remotely from the software and locally via the device push-button.

G. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.

H. Sensors shall have optional features for photosensor/daylight override, automatic dimming control, and low temperature/high humidity operation.

I. Photosensor shall provide for an on/off set-point, and a dead band to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.

J. Photosensor and dimming sensor’s set-point and dead band shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.

K. Dead band setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).

L. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The secondary daylight zone shall be capable of being controlled as an “offset” from the primary zone.

M. Outdoor photo sensor shall have weatherproof housing.

2.09 WIRED NETWORKED POWER PACKS AND SECONDARY PACKS

A. Power Packs shall incorporate one optional Class 1 relay, optional 0-10 VDC dimming output, and contribute low voltage Class 2 power to the rest of the system.

B. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC) and carry a plenum rating.

C. Secondary Packs shall incorporate the relay and 0-10 VDC or line voltage dimming output, but shall not be required to contribute system power.

D. Communication shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors. Secondary packs shall receive low voltage power via standard low voltage network cable.

E. Power Pack programming parameters shall be available and configurable remotely from the software and locally via the device push-button.

F. Power Pack shall securely mount through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast/driver channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.

G. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

H. Power and Secondary Packs capable of full 20-Amp switching of general-purpose receptacle (plug-load) control.

2.10 INDOOR OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide as listed per each sensor type or comparable product by one of the following:

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Acuity Brands Lighting, Inc.
4. Lutron Electronics Co., Inc.

B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes.
   3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
   4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
   5. Mounting:
      a. Sensor: Suitable for mounting in any position on a standard outlet box.
      b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
      c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
   7. Bypass Switch: Override the "on" function in case of sensor failure.
   8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. PIR Type: Ceiling mounted; detect occupants in coverage area by their heat and movement. All sensors tested per NEMA WD7 standards. (WattStopper CI-300)
   1. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 square inch.
   2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. foot when mounted on a 96-inch-high ceiling.
   3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot-high ceiling.
   4. Normally open/normally closed contacts available for 3rd party integration.

D. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy. All sensors tested per NEMA WD7 standards. (WattStopper WT-600; WT-1100; WT2200)
   1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inch/es.
   2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 square foot when mounted on a 96-inch-high ceiling.
   3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 square foot when mounted on a 96-inch-high ceiling.
   4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 square foot when mounted on a 96-inch-high ceiling.
   5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot-high ceiling in a corridor not wider than 14 feet.

6. Normally open/normally closed contacts available for 3rd party integration.

E. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. All sensors tested per NEMA WD7 standards. PIR and ultrasonic are the only acceptable technologies. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit. (WattStopper DT-300)

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 square inches and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inch/es.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 square feet when mounted on a 96-inch-high ceiling.
4. Normally open/normally closed contacts available for 3rd party integration.

2.11 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide as listed per sensor type or comparable product by one of the following:

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Acuity Brands Lighting, Inc.
4. Lutron Electronics Co., Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 degrees F.

C. Wall-Switch Sensor Tag SOP:

1. Standard Range: 180-degree field of view, with a minimum coverage area of 10’x15’.
2. Sensing Technology: PIR.
3. Switch Type: field selectable automatic "on," or manual "on," automatic "off."
4. Voltage: Dual voltage, 120 and 277 V.
5. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
6. Concealed, field-adjustable, "off" time-delay selector between 1and 30 minutes.

D. Wall-Switch Sensor Tag SO:

1. Standard Range: 180-degree field of view, with a minimum coverage area of 10 feet x 15 feet.
2. Sensing Technology: Dual technology.
3. Switch Type: field selectable automatic "on," or manual "on," automatic "off."
4. Voltage: Dual voltage, 120 and 277 V
5. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.

6. Concealed, field-adjustable, "off" time-delay selector between 1 and 30 minutes.

2.12 HIGH-BAY OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide WattStopper HB Series or comparable product by one of the following:
   1. Cooper Industries, Inc.
   2. Hubbell Building Automation, Inc.
   3. Acuity Brands Lighting, Inc.

B. General Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Operation: Turn lights on when coverage area is occupied, and to off when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 30 minutes.
   3. Operating Ambient Conditions: 32 to 149 degrees F.
   4. Mounting: Threaded pipe.
   5. Detector Technology: PIR.

C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet.

2.13 OUTDOOR MOTION SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide WattStopper EW Series or comparable product by one of the following:
   1. Cooper Industries, Inc.
   2. Hubbell Building Automation, Inc.
   3. Acuity Brands Lighting, Inc.

B. General Requirements for outdoor motion sensors.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. PIR type, weatherproof. Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 square inches. Comply with UL 773A.
   3. Switch Rating:
      a. Lighting-Fixture-Mounted Sensor: 500-VA fluorescent.
      b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
   4. Voltage: Match the circuit voltage type.
   5. Detector Coverage:
      a. Standard Range: 270-degree field of view, with a minimum coverage area of 40 feet.
   6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
   7. Concealed, field-adjustable, "off" time-delay selector between 1 and 30 minutes.

8. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 degrees F, rated as "raintight" according to UL 773A.

2.14 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two lighting conditions:

a. When no daylight is present (target level).

b. When significant daylight is present.

2.15 EMERGENCY SHUNT RELAY

A. Basis-of-Design Product: Subject to compliance with requirements, provide WattStopper ELCU-200 or comparable product by one of the following:

1. Bodine

2. Functional Devices.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 277 V.

2.16 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. CAT5e cabling plenum rated to interconnect system devices and controllers.

PART 3 - EXECUTION

3.01 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions. Ultrasonic sensors to remain minimum of 6 feet from supply air.

C. Provide and install the lighting control system components according to the manufacturer’s installation instructions, wiring diagrams, project submittals and plans specifications.

3.02 WIRING INSTALLATION

A. Wiring Method: Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

D. Comply with manufacture cabling installation requirements for CAT5 wired devices.

E. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.03 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Verify occupancy sensors operate per design intent.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. CAT5 wired devices, low voltage network cable testing shall be performed prior to system startup.

D. System start-up and programming shall include:

1. Verifying operational communication to all system devices.
2. Programming devices into functional control zones to meet the required sequence of operation.
3. Programming and verifying all sequence of operations.

E. Initial start-up and programming is to occur on-site.

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Prepare test and inspection reports.
3. Prepare test and inspection reports.

3.05 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

3.06 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following types of dry-type transformers with primary voltages rated 600 V and less:
   1. Distribution transformers.
   2. Harmonic mitigating transformers.

1.03 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, loss data, sound level, insulation system type, rated temperature rise and efficiency performance for each type and size of transformer indicated.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

B. Comply with the following standards:
   1. NEMA ST 1 – Specialty Transformers.
   2. NEMA ST 20 – Dry Type Transformers for General Applications.
   3. ANSI/IEEE C57.12.01 – General Requirements for Dry Type Distribution and Power Transformers.
   4. ANSI/IEEE C57.12.91 – Test Code for Dry-Type Distribution and Power Transformers.

C. All transformers shall be listed by Underwriters Laboratories and bear the UL label.

D. Provide transformers that are constructed to withstand seismic forces specified in Section 13 05 41 "Seismic Restraints."

E. Base kVA rating shall not be obtained by use of fans or other external cooling methods.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Handle transformers in accordance with manufacturer’s recommendations. Utilize factory provisions for all lifting, rigging or hoisting.

B. Store transformers prior to installation in a temperature and humidity controlled space with the ventilation openings covered to mitigate dust intrusion. If such a space is not available, apply temporary heat in accordance with manufacturer’s instructions within each ventilated type transformer case to exclude moisture and condensation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Cutler-Hammer.
   2. Federal Pacific.
   3. Siemens Energy & Automation, Inc.
   4. Square D Co.
   5. General Electric.

2.02 DISTRIBUTION TRANSFORMERS

A. Description: DOE 2016 Efficiency compliant, General purpose, self-cooled, two winding, dry type designed for 60Hz operation.

B. Insulation System:
   1. 220 degrees C, with a maximum of 115-deg. C rise above 40-deg. C ambient temperature.

C. Core: High-grade, non-aging, silicon steel with high magnetic permeability and low hysteresis and eddy current losses.

D. Coils: Continuous windings with brazed or welded terminations.
   1. Coil Material: Copper.

E. Grounding:
   1. Core and coil assembly shall be grounded by means of a flexible safety ground strap or conductor.
   2. All transformer grounding and bonding connects shall be made to a ground bus bar secured inside the transformer enclosure. Refer to Division 26 section “Grounding and Bonding” for ground bus bar requirements.

F. Electrostatic Shielding: Independent, single, full-width electrostatic shield placed between each primary and secondary winding and ground. Provide as shown on drawings.

G. Winding Taps: Rated for full capacity on primary winding.
   1. Transformer size less than 15kVA: Minimum of two (2) 5 percent below normal rated voltage.
   2. Transformer size greater than 15kVA and less than 750kVA: Minimum of two (2) 2-1/2 percent above and four (4) 2-1/2 percent below normal rated voltage.

H. Enclosure: NEMA ST 20, Type 1, front and rear removable covers.
   1. Core and coil assembly shall be isolated from the enclosure utilizing rubber vibration dampening pads.
   2. Each transformer shall have a securely attached nameplate providing complete electrical ratings, wiring diagram, tap connections and catalog number as applicable.
   3. The maximum temperature of the enclosure shall not exceed 90 degrees C.

I. Mounting Capability: Suitable for the following:
   1. Transformer size less than 75kVA: Wall, Floor or Trapeze.
   2. Transformer size greater than 75kVA: Floor or Trapeze.

J. Sound Levels: Shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

kVA Rating	Sound Levels
0 – 9 kVA	40 dB
10-50 kVA	45 dB
51-150 kVA	50 dB
151-300 kVA	55 dB
301-500 kVA	60 dB
501-700 kVA	62 dB
701-1000 kVA	64 dB
1001-1500 kVA	65 dB

2.03 HARMONIC MITIGATING TRANSFORMERS

A. Description: NEMA TP1; NEMA ST 20, air cooled, ventilated, dry type, 200 percent rated neutral, 10kV BIL, designed for 60Hz operation.

B. Insulation System: 220 degrees C, with a maximum of 115-deg. C rise above 40-deg. C ambient temperature.

C. Core: High-grade, non-aging, silicon steel with high magnetic permeability and low hysteresis and eddy current losses.

D. Coils: Continuous windings with brazed or welded terminations.
   1. Coil Material: Copper.

E. Grounding: Core and coil assembly shall be grounded by means of a flexible safety ground strap or conductor.

F. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

G. Electrostatic Shielding (K-Rated): Independent, single, full-width electrostatic shield placed between each primary and secondary winding and ground.

H. Winding Taps: Rated for full capacity on primary winding.
   1. Transformer size 15kVA to 300kVA: Minimum of two (2) 2-1/2 percent above and two (2) 2-1/2 percent below normal rated voltage.

I. Phase Shift: Transformer shall be capable of providing a phase shift of 0 degrees or 30 degrees. Provide phase shift of harmonic mitigating transformers wired in parallel from the same distribution source.

J. Enclosure: NEMA ST 20, Type 1, front and rear removable covers.
   1. Core and coil assembly shall be isolated from the enclosure utilizing rubber vibration dampening pads.
   2. Each transformer shall have a securely attached nameplate providing complete electrical ratings, wiring diagram, tap connections and catalog number, as applicable.
   3. The maximum temperature of the enclosure shall not exceed 90 degrees C.

K. Mounting Capability: Suitable for the following:
   1. Transformer size less than 75kVA: Wall, Floor or Trapeze.
   2. Transformer size greater than 75kVA: Floor or Trapeze.

L. Sound Levels: Shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

kVA Rating	Sound Levels
15 -10 kVA	42 dB
51-150 kVA	47 dB
151-300 kVA	52 dB

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install transformers level and plumb. Utilize a maximum of 2 feet-0 inches of flexible conduit for connections to side of transformer case.

B. Identify transformers and install warning signs according to Division 26 Section "Identification for Electrical Systems."

C. Use lugs rated for 75 degree Celsius when connecting conductors to transformer.

3.03 FIELD QUALITY CONTROL

A. Schedule tests and provide notification at least one week in advance of test commencement.

B. Tests: Include the following minimum inspections and tests according to the manufacturer's instructions.
   1. Inspect accessible components for cleanliness, mechanical and electrical integrity, for presence of damage or deterioration and to ensure removal of temporary shipping bracing. Do not proceed with tests until deficiencies are corrected.
      a. Include internal inspection through access panels and covers.
      b. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, where not available, those of UL standards 486A and 486B.
   2. Insulation Resistance: Perform megohmmeter test of primary and secondary winding-to-winding and winding-to-ground. Use a minimum test voltage of 1,000 V D.C. Minimum insulation resistance is 500 megohms.
   3. Duration of Each Test: 10 minutes.
   4. Temperature Correction: Correct results for test temperature deviation from 20 degrees C standard.

C. Test Failures: Correct deficiencies identified by tests and retest. Verify that equipment meets the specified requirements.

D. Submit certification that tests have been performed.

E. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies and equipment installations including connections and to assist in testing.

F. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

G. Remove and replace units that do not pass tests or inspections and retest as specified above.

H. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.04 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions.

3.05 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 24 13
SWITCHBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Instrumentation.
   3. Control power.
   4. Accessory components and features.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to Section 13 05 41 “Seismic Restraints.”
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.04 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Product data for each product and component specified.
   2. Shop drawings for each switchboard including dimensioned plans and elevations, component and device lists, and a one-line diagram showing main and branch bus current ratings and short-time and short circuit ratings of switchboard.
   3. Shop drawings of utility company (Ameren) metering provisions with indication of approval by utility company.
   4. Manufacturer's Schematic Wiring Diagram.
   5. Point-to-Point Control Wiring Diagram: Differentiating between manufacturer-installed and field-installed wiring (may be submitted upon delivery of switchboard).
   6. Report of field tests and observations certified by the testing organization.
   7. Maintenance data for materials and products, for inclusion in Operating and Maintenance Manual specified in Division 01 and in Division 26 Section "Common Work Results for Electrical."

B. Shop Drawings: For each switchboard and related equipment.
   1. Include dimensioned plans, elevations, sections and details including required clearances and service space around equipment. Show tabulations of installed devices, equipment features and ratings.
   2. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current and voltage ratings.
   4. Detail short circuit current rating of switchboards and overcurrent protective devices.
   5. Detail utility company's metering provisions with indication of approval by utility company.
   6. Detail features, characteristics, ratings and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit electronically compatible with SKM PowerTOOL’s software; include selectable ranges for each type of overcurrent protective device.

8. Include schematic and wiring diagrams for power, signal and control wiring.

C. Seismic Qualification Certificates: Submit certification from manufacturer that switchboards, overcurrent protective devices, accessories and components will withstand seismic forces defined in Section 13 05 41 "Seismic Restraints." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Operation and Maintenance Data: For switchboards and components to include in emergency, operation and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for switchboards and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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

D. Comply with NEMA PB 2 “Deadfront Distribution Switchboards.”

E. Comply with NFPA 70 “National Electrical Code.”

F. Comply with UL 891 “Deadfront Switchboards.”

G. Listing and Labeling: Provide switchboard assemblies that are listed and labeled by Underwriters Laboratories for the specific purpose.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under provisions of Section 26 0500.

B. Deliver in 48-inch maximum width shipping splits unless approved otherwise by both the Contractor and Engineer, individually wrapped for protection and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 0500.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris and traffic.

E. Handle in accordance with NEMA PB2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure and finish.

F. Handle and prepare switchboards for installation according to NECA 400 and NEMA PB 2.1 "General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards." Use factory-installed lifting provisions.

1.07 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight; work in spaces is complete and dry; work above switchboards is complete; and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104 degrees F (40 degrees C).
      b. Altitude: Not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Owner no fewer than fourteen days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without Owner's written permission.
   4. Comply with NFPA 70E.

1.08 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.01 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. General Electric.
   2. ABB Power Distribution, Inc.
   3. Eaton.
   4. Siemens Energy & Automation, Inc.
   5. Square D Co.

B. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Fixed, individually mounted.
   2. Branch Devices: Panel mounted.
   3. Sections front and rear aligned.

C. Provide nominal system voltage, continuous main bus amperage, and short circuit current ratings as indicated on the Drawings.

D. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 13 Section "Seismic Restraints."

E. Indoor Enclosures: Steel, NEMA 250, Type 1.

F. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

G. Barriers: Between adjacent switchboard sections.

H. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

I. Utility (Ameren) Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers, or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

J. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door for indicated metering and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.

K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

L. Hinged Front Panels: Allow access to circuit breaker, metering, accessory and blank compartments.

M. Buses and Connections: Three-phase, four-wire unless otherwise indicated.
   1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver plated.
   2. Ground Bus: 1 inch x 1-1/4 inch, hard-drawn copper of 98 percent conductivity equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
   3. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
   4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
   5. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

N. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.02 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Refer to one-line diagram for additional requirements.

B. Circuit Breaker Frames Rated 1200 Amperes or Larger
   1. Breakers that have a continuous overcurrent trip rating or setting of 1200A or higher shall include:
      a. Energy-reducing maintenance switching with local status indicator.
      b. Energy-reducing active arc flash mitigation system.

C. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Provide breaker interrupting ratings as indicated on the plans. Where necessary to meet interrupting ratings, breakers shall be provided with automatically resetting current limiting elements in each pole.

D. Solid State Molded Case Circuit Breakers: All breakers identified on plans as solid-state with with adjustable LSIG. Provide molded case switch with electronic sensing, timing and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip and short time delay. Trip setting shall be field programmable with a sealable clear cover. Provide stationary mounting. Ground fault sensing shall be breaker integral with circuit breaker. Provide zero sequence type ground fault sensor. Provide breaker interrupting ratings as indicated on the plans. Main circuit breakers shall be 100% rated in conjunction with the switchboard bus.

2.03 INSTRUMENTATION

A. Current Transformers: ANSI C57.13; 5 ampere secondary, bar or window type with single secondary winding, unless otherwise required for application and secondary shorting device, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: ANSI C57.13; 120-volt single secondary, disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

C. Ground Fault Sensor: Zero sequence type.

D. Ground Fault Relay: Adjustable ground fault sensitivity from 200 to 1200 amperes, time delay adjustable from 0 to 15 seconds.

E. Digital AC Power Monitor capable of measuring, calculating and directly displaying: Volts (L-L, L-N), Amps, KW, KWH. Monitor shall be true RMS measurement with programmable set-up parameters. All set-up parameters data shall be stored in non-volatile memory to protect from power outages. Monitor shall be provided with communication capability with an 10/100 Base Tx UTP port, and an RS485 Modbus Serial Master port.

2.04 CONTROL POWER

A. Control Circuits: 120-V A.C., supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing and protection included. Provide flexible conductors for No. 8 AWG and smaller for conductors across hinges and for conductors for interconnections between shipping units.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1 and in accordance with manufacturers' written installation instructions and the following specifications.

A. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for Concrete Bases specified in Division 26 Section "Common Work Results for Electrical."

B. Anchor each switchboard assembly to slab or housekeeping pad (as indicated) using bolt sizes and types and quantities as recommended by manufacturer and to meet seismic force requirements. When secured to a pad that is separately poured, the bolts are to be installed through the pad and into the slab. Use appropriate length bolts.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 13 Section "Seismic Restraints."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Comply with NECA 1.

3.02 GROUNDING

A. Connections: As indicated. Tighten connections to comply with tightening torques specified in UL 486A.

A. Ground equipment according to the contract documents and the National Electrical Code.

3.03 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

C. Tighten switchboard bus joint bolts and electrical connector and terminal bolts in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not stated, use those specified in UL 486A and UL 486B.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

A. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Device Nameplates: Label each disconnecting, and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section “Identification for Electrical Systems.”

3.05 FIELD QUALITY CONTROL

A. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

B. Measure insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute each. Test voltage shall be 1000 volts and minimum acceptable value for insulation resistance is 2 megohms.

C. Check tightness of accessible bolted bus joints using a calibrated torque wrench. Tightness shall be in accordance with manufacturer's recommended values.

D. Physically test key interlock systems to ensure proper function.

3.06 ADJUSTING

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

A. Set field-adjustable circuit-breaker trip ranges as indicated on the drawings or as instructed by the engineer.

3.07 CLEANING

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

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to Section 13 05 41 “Seismic Restraints.”

1.04 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections and details. Show tabulations of installed devices, equipment features and ratings such as voltage, main bus ampacity, integrated short circuit ampere rating, overcurrent protective device arrangement and sizes.
   2. Include make and model of the main breaker and trip unit.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 13 Section "Seismic Restraints."

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1 “Panelboards.”

E. Comply with NFPA 70 “National Electrical Code.”

1.06 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.07 WARRANTY

A. Warranty: Panelboard and components shall be warranted to be free from manufacturing defects for a period of one year after project acceptance by Owner.

1.08 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 13 05 41 "Seismic Restraints."

B. Enclosures: NEMA PB 1, Type 1, flush or surface mounted as shown on drawings.
   1. Rated for environmental conditions at installed location, unless otherwise noted on drawings, the following types shall be used in the listed locations:

Location	NEMA Type
Dry, clean indoor	NEMA 1
Outdoor or Damp or wet interior locations	NEMA 3R
Indoor or outdoor corrosive areas or areas subjected to hose streams	NEMA 4X
Dusty indoor areas	NEMA 12

   2. Finishes:
      a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Same finish as panels and trim.
   3. Directory Card: Inside panelboard door, mounted in transparent card holder.

C. Phase, Neutral, and Ground Buses:
   1. Material: Copper.
   2. Main bussing shall be fully rated, non-tapered, ready to receive those overcurrent devices indicated as spaces without modifying the bus. Neutral bus to be rated at 100 percent of the main bus rating, capable of accepting terminations based on the maximum number of branch circuit protective devices allowed in the panelboard plus 6 additional conductors.
   3. Equipment Ground Bus: Adequate for panelboard feeder and branch-circuit equipment ground conductors. Equipment ground bus shall be large enough and have sufficient quantity and sizes of terminations to allow for termination of panelboard feeder plus one equipment-grounding conductor per circuit, based on the maximum number of branch circuit protective devices allowed in the panelboard plus 6 additional conductors. Increase terminations to accommodate additional feeder conductors where double-lugged panelboards are indicated. When panelboards are multiple sections, provide equipment ground busses in each section of sufficient size for all grounding conductors in that section. Ground busses to be insulated from the panelboard enclosure where isolated ground busses are called for. Ground busses shall be bonded to enclosure when isolated ground buses are not called for.
   4. Extra-Capacity Neutral Bus: Where scheduled on drawings, provide neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear load.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Main, Neutral, and Ground Lugs and Buses: Provide mechanical connectors for conductors. Provide necessary additional wire bending and terminating space when sub-feed and feed-through lugs are called for.

E. Future Devices: Mounting brackets, bus connections, filler plates and necessary appurtenances required for future installation of devices.

F. Overcurrent Protection Devices: Multiple pole overcurrent protection devices shall be provided with a common trip handle for all poles. Tandem circuit breakers are not allowed.

G. Panelboard Short-Circuit Current Rating: All distribution and branch circuit panelboards shall be fully rated to interrupt symmetrical short circuit current available at terminals. Series rated equipment is not allowed.

2.02 DISTRIBUTION PANELBOARDS

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

240/120V 208Y/120V 480Y/277V and 480 V rated panelboards:

Manufacturer	Panelboard
General Electric	Spectra Series
Siemens	P series
Square D	QMB/I-Line
Cutler-Hammer	Pow-R-Line 4F

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

D. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents. Refer to one-line diagram for additional requirements.
1. Circuit Breakers: Provide molded-case, thermal-magnetic, trip-free, bolt-on circuit breakers (unless otherwise noted), replaceable without disturbing adjacent units. Circuit breaker escutcheon shall have ON and OFF markings. Circuit breaker handle accessories shall provide provisions for locking handle in the "ON" or "OFF" position. Circuit breaker faceplate and handle shall indicate rated ampacity. Circuit breaker faceplate shall indicate UL certification standards with applicable voltage systems and corresponding AIC ratings. Circuit breakers 30 amperes and less shall be UL listed to accept copper conductors with insulation rated at 60, 75 and 90 degrees Celsius, with conductors sized from the 60 degree Celsius column of Table 310.15(B)(16) of the NEC. Circuit breakers larger than 30 amperes shall be UL listed to accept copper conductors with insulation rated at 75 or 90 degrees Celsius with conductors sized from the 75 degree Celsius column of Table 310.16 of the NEC.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field adjustable trip setting.
4. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.

b. Long- and short-time pickup levels.
c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I^2t response.

E. Short Circuit Rating: Provide short circuit rating for each panelboard as indicated on drawings. Ratings indicated are minimum values. Manufacturer shall provide the next larger rating if the value indicated is unavailable.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Doors: Hinged front cover, entire front trim hinged to box and with standard door within concealed hinged trim cover (door-in-door). Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Provide flush locks, keyed alike.

D. Interiors: Provide physical means to prevent installation of more overcurrent protection devices than the quantity for which the enclosure was listed. Interiors shall be field convertible for top or bottom feed.

E. Box: Box shall be nominally 5-3/4 inches deep by 20 inches wide.

F. Circuit Numbering: Provide factory fabricated circuit numbers adjacent to each circuit breaker pole position. Numbering shall be continuous from topmost pole position to last possible pole position. Number sequence on left shall be 1-3-5-7, etc., and number sequence on right shall be 2-4-6-8, etc. Numbering material shall be insertable or strip type, as manufactured by the panelboard manufacturer for the specific panelboard. Adhesive markers and pen type markers are not acceptable.

G. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Circuit Breakers: Provide molded-case, thermal-magnetic, trip-free, bolt-on circuit breakers (unless otherwise noted) replaceable without disturbing adjacent units. Circuit breaker escutcheon shall have ON and OFF markings. Circuit breaker handle accessories shall provide provisions for locking handle in the "ON" or "OFF" position. Circuit breaker faceplate and handle shall indicate rated ampacity. Circuit breaker faceplate shall indicate UL certification standards with applicable voltage systems and corresponding AIC ratings. Circuit breakers 30 amperes and less shall be UL listed to accept copper conductors with insulation rated at 60, 75 and 90 degrees Celsius, with conductors sized from the 60 degree Celsius column of Table 310.15(B)(16) of the NEC. Circuit breakers larger than 30 amperes shall be UL listed to accept copper conductors with insulation rated at 75 or 90 degrees Celsius with conductors sized from the 75 degree Celsius column of Table 310.16 of the NEC.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits; Type HACR for feeding heating, air conditioning or refrigeration loads. Provide UL Class A ground fault interrupter circuit breakers where scheduled on drawings. Arc fault circuit breakers shall comply with UL 1699; 120/240-V, single-pole configuration.

H. Short Circuit Rating: Provide short circuit rating for each panelboard as indicated on drawings. Ratings indicated are minimum values. Manufacturer shall provide the next larger rating if the value indicated is unavailable.

2.04 OVERCURRENT PROTECTIVE DEVICE ACCESSORY OPTIONS

A. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

B. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in the “ON” or “OFF” position.

C. Handle Clamp: Loose attachment for holding circuit-breaker handle in on position.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

B. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Section 13 05 41 "Seismic Restraints."

C. Mounting height: Mount panelboards such that the center grip of any operating handle, when in its highest position, is not more than 79 inches above the floor. Align top edges of panelboard covers where multiple panelboards are installed in the same general area.

D. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit breaker trip ranges as dictated on drawings.

E. Install filler plates in unused spaces.

3.03 IDENTIFICATION

A. Comply with requirements within Division 26 Section "Identification for Electrical Systems."

B. Circuit Directory: Provide typed circuit directory reflective of final circuit changes. Identify all circuits including spares. Spaces shall be left blank. Circuit designations shall describe the load type and location. For example, “Lighting - North Corridor” or “Receptacles - Rooms A, B, C and X, Y, Z.” Use Owner's room designations, not designations shown on the plans, if different. Type on cardboard stock installed behind clear acrylic holder enabling removal of the directory.

3.04 FIELD QUALITY CONTROL

A. Visual and Mechanical Inspection: Include the following inspections and related work:
   1. Inspect for defects and physical damage, labeling and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
   2. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
   3. Check panelboard mounting, area clearances, alignment and fit of components.
   4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Manual motor starters.

B. Magnetic motor starters.

C. Combination magnetic motor starters.

1.03 SUBMITTALS

A. Product Data: For each type of controller and each type of MCC. Include shipping and operating weights, features, performance, electrical ratings, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
   1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Factory-installed devices.
      c. Enclosure types and details.
      d. Nameplate legends.
      e. Each starter and switch shall have a nameplate with the same mark (designation) as indicated on the construction documents. Refer to Specification Section 26 0553.
      f. Short circuit current (withstand) rating of each unit.
      g. Features, characteristics, ratings and factory settings of each installed controller and feeder device, and installed devices.
      h. Specified optional features and accessories.
   2. Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
   3. Nameplate legends.
   4. Features, characteristics, ratings, and factory settings of each installed unit.

C. Warranty: Sample of special warranty.

D. Submit manufacturer's instructions under provisions of Section 26 0500.

1.04 OPERATION AND MAINTENANCE DATA

A. Operation and Maintenance Data: Include data for all installed devices, and components to include in operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:
   1. Manufacturer's Record Drawings: Include field modifications incorporated during construction by manufacturer, Contractor, or both.
   2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
   3. Manufacturer's written instructions for setting field-adjustable overload relays.
   4. Manufacturer's written instructions for testing, adjusting and reprogramming microprocessor control modules.

5. Manufacturer's written instructions for setting field-adjustable timers, controls and status and alarm points.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site.

B. Deliver in 60 inch maximum width shipping splits, or per site restrictions, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from fumes, dirt, water, construction debris, traffic and physical damage.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure and finish.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allen-Bradley Co.
2. Cutler-Hammer.
3. General Electric Co.
4. Square D Co.
5. Siemens.

2.02 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; AC general purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with overload relay and toggle operator.

B. Fractional Horsepower Manual Starter: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit and toggle operator.

C. Motor Starting Switch: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors without thermal overload unit and toggle operator.

D. Enclosure: NEMA ICS 6; Type 1.

2.03 MAGNETIC MOTOR STARTERS

A. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

B. Full Voltage Starting: Non-reversing type unless otherwise indicated.

C. Coil Operating Voltage: 120 volts, 60 Hertz, obtained from integral control power transformer of sufficient capacity to operate connected pilot, indicating, and control devices, plus 100 percent spare capacity.

D. Size: NEMA ICS 2; size as shown on the drawings.

E. Overload Relay:
1. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class **10** tripping characteristic and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-

fault protection, phase loss protection, with start and run delays to prevent nuisance trip on starting.

F. Enclosure: NEMA ICS 6 Type 1.

G. Combination Motor Starters: Combine motor starters with disconnect switch in common enclosure. Provide with disconnecting means as indicated on drawings.

H. Auxiliary Contacts: NEMA ICS 2; two normally open, field convertible contacts in addition to seal-in contact.

I. Pushbuttons: Heavy Duty NEMA ICS 2; START/STOP in front cover.

J. LED Indicating Lights: NEMA ICS 2; RUN: red in front cover; OFF: green in front cover.

K. Selector Switches: Heavy Duty NEMA ICS 2; HAND/OFF/AUTO, in front cover.

L. Relays: NEMA ICS 2

M. Control Power Transformers: 120 volt fused secondary, fused primary, minimum VA as scheduled:
   1. Size 1: 100 VA.
   2. Size 2: 100 VA.
   3. Size 3: 150 VA.

2.04 CONTROLLER OVER-CURRENT PROTECTION AND DISCONNECTING MEANS

A. Molded Case Thermal Magnetic Circuit Breakers: Circuit breakers with integral thermal and instantaneous magnetic trip in each pole. NEMA AB 1, motor-circuit protector with field-adjustable, short circuit trip coordinated with motor locked-rotor amperes.

B. Non-fusible Switch Assemblies: Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions.

B. Set field-adjustable switches and circuit-breaker trip ranges per drawings or Engineer’s instructions.

C. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor and voltage/phase rating.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:
   1. Receptacles, receptacles with integral GFCI and associated device plates.
   2. Twist-locking receptacles.
   3. Snap switches and wall-box dimmers.
   4. Solid state fan speed controls.
   5. Pendant cord-connector devices.
   6. Cord and plug sets.
   7. Floor service outlets, poke-through assemblies, service poles and multi-outlet assemblies.

1.03 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.04 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Comply with NFPA 70.

C. Comply with UL 498: “Attachment Plugs and Receptacles.”

D. Comply with UL 943: “Ground-Fault Circuit-Interrupters.”

E. Listing and Labeling: Provide products which are listed and labeled by Underwriters Laboratories for their applications and installation conditions and for the environments in which installed.

1.06 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.01 WIRING DEVICES

A. Comply with NEMA Standard WD 1, "General Purpose Wiring Devices" and NEMA Standard WD6 “Wiring Device Dimensional Requirements.”

B. Enclosures: NEMA 1 equivalent, except as otherwise indicated.

C. Receptacles, Straight-Blade and Locking Type: Except as otherwise indicated, comply with UL Standard 498, "Electrical Attachment Plugs and Receptacles." Provide UL labeling of devices to verify these compliances. Provide straight blade receptacles per table on the following page.

D. Any receptacles that are controlled by an automatic control device shall have the centralized receptacle marking furnished with the device or cover plate.

2.02 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper: 5352.
      b. Hubbell: 5352.
      c. Leviton: 5352.
      d. Pass & Seymour: 5362.

B. Receptacles, Industrial Heavy-Duty: Conform to NEMA Standard PK 4 "Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type for Industrial Use" and IEC 309.

2.03 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper: VGF20.
      b. Hubbell: GF20L.
      c. Leviton: GFNT2.
      d. Pass & Seymour: 2095.

C. Weather-Resistant, Duplex GFCI Convenience Receptacles:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper: WRVGF20.
      b. Hubbell: GFTR20.
      c. Leviton: GFWR2.
      d. Pass & Seymour: 2095WR.

2.04 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Receptacles in Hazardous (Classified) Locations: Comply with NEMA Standard FB 11 "Plugs, Receptacles and Connectors of the Pin and Sleeve Type for Hazardous Locations" and UL Standard 1010 "Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations."
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cooper Crouse-Hinds.
      b. EGS/Appleton Electric.
      c. Killark; a division of Hubbell Inc.

2.05 TWIST-LOCKING RECEPTACLES

A. Locking or special type to be of NEMA configuration called out for the specific application on the drawings.

B. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper: L520R.
      b. Hubbell: HBL2310.
      c. Leviton: 2310.
      d. Pass & Seymour: L520-R.

2.06 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
   1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
   2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.07 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   1. Cord: Rubber-insulated, stranded-copper conductors with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
   2. Plug: Male configuration with nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.08 SNAP SWITCHES

A. Snap Switches: Quiet-type a.c. switches, Underwriters Laboratories listed and labeled as complying with UL Standard 20 "General Use Snap Switches.” Switches shall be heavy duty industrial rated, 20A, 120/277V, ivory handle, back and side wired, number of poles as required, with ground screw.

B. Comply with NEMA WD 1 and UL 20.

C. Switches, 120/277 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper: AH1221 (single pole), AH1222 (two pole), AH1223 (three way), AH1224 (four way).
      b. Hubbell: HBL1221 (single pole), HBL1222 (two pole), HBL1223 (three way), HBL1224 (four way).
      c. Leviton: 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
      d. Pass & Seymour: 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

D. Pilot Light Switches, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper: 2221PL for 120 V and 277 V. [
      b. Hubbell: HBL1221PL for 120 V and 277 V.
      c. Leviton: 1221-PLR for 120 V, 1221-7PLR for 277 V.
      d. Pass & Seymour: PS20AC1-PLR for 120 V.

2. Description: Single pole, with lighted handle, illuminated when switch is "ON."

E. Snap Switches in Hazardous (Classified) Locations: Comply with UL Standard 894, "Switches for Use in Hazardous (Classified) Locations."

2.09 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

2.10 FAN SPEED CONTROLS

A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
1. Continuously Adjustable Slider: 5 A.
2. Three-Speed Adjustable Slider: 1.5 A.

2.11 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Device Enclosures for Outdoor and Other Wet and Damp Locations: Enclosure shall be suitable for wet locations while in use in accordance with Article 406.8 (B) and listed and labeled for the specific use by Underwriters Laboratories. Enclosure shall be clearly and visibly marked by the factory with the wording "Suitable For Wet Locations While In Use." Enclosure shall be non-metallic with hinged clear cover and integral key operated cover lock. Cover to have two exit holes for up to 3/8 inch diameter cords with holes located at bottom of cover. Provide cover with device opening matched to type of wiring device used, e.g., duplex receptacle, GFCI receptacle, and toggle switch.

C. Color: Match wiring device except as otherwise indicated.

2.12 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type with flap-type cover, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular Solid brass with satin finish.

2.13 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell.
2. Walker.
3. Wiremold.
4. Thomas & Betts.

B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
1. Service Outlet Assembly: Flush type with two duplex receptacles and space for four RJ-45 jacks.

2. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: For a minimum of four No. 12 THHN AWG conductors and a minimum of four, 4-pair, Category 6 voice and data communication cables.
6. Cover Options Brass.

2.14 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.
   1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1 including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint and other material that may contaminate the raceway system, conductors and cables.
   3. Install device boxes in brick or block walls so that the coverplate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete. Protect devices and assemblies during painting if installed prior to wall painting.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Install devices and assemblies plumb and secure.
11. Install wall plates when painting is complete.
12. Utilize weather-resistant receptacles in wet or damp locations and outdoors.
13. For all devices mounted flush in walls where communications backboards are installed, provide extension ring with sufficient depth for the outlet and coverplate to mount flush to the face of the communications backboard. Devices and coverplates that mount recessed to the communications backboard are not acceptable.
14. Provide GFCI receptacles when installed within 6 ft. of the outside edge of a sink.

E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors online and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943 and per manufacturer’s recommendations.
5. Test wiring devices for proper polarity and ground continuity. Operate each operable device at least 6 times.
6. Using the test plug, verify that the device and its outlet box are securely mounted.
7. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or

similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones and retest as specified above.

8. Replace damaged or defective components.

3.04 CLEANING

A. General: Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION

SECTION 26 28 16
ENCLOSED SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Fusible and Non-fusible switches.
   2. Molded-case circuit breakers.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to Division 13 “Seismic Restraints.”
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.04 SUBMITTALS

A. Submittals for approval by the Engineer are not required for this section. Unrequested submittals will not be processed or reviewed. Non-requirement of submittals is not to be construed as an allowance for substitutions and does not allow relief from full compliance with the contract documents.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components and accessories within same product category from single source and from single manufacturer.

B. Electrical Component Standards: Provide components complying with NFPA 70 "National Electrical Code" and which are listed and labeled by UL. Comply with UL Standard 98 and NEMA Standard KS 1.

1.06 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.01 MANUFACTURERS - GENERAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Cutler-Hammer.
   2. General Electric.
   3. Square D Company.
   4. Siemens.

2.02 FUSIBLE AND NONFUSIBLE SWITCHES

A. General: Provide circuit and motor disconnect switches in types, sizes, duties, features, ratings, enclosures and accessories as indicated within Disconnect Schedule, located on the drawings.

B. Fusible and Non Fusible Switches: Type HD heavy-duty, quick-make, quick-break load interrupter enclosed knife switch, externally operable, lockable handle, interlocked with cover in

closed position. Unless indicated otherwise, provide 3-blade with solid neutral when a neutral is provided. Compliant with NEMA KS 1.

C. Provide positive pressure, reinforced Type Class R fuse clips for fusible switches 600 amps or less to prevent other than UL Class RK current limiting fuses. Provide for Class L fuses for switches over 600A.

D. Service Switches: Shall be as above but shall also be UL listed for use as service equipment under UL Standard 98 or 869.

E. Switches for Classified (Hazardous) Locations: Heavy-duty switches as above with UL labels and listings for hazardous location classifications in which installed.

2.03 MOLDED-CASE CIRCUIT BREAKERS

A. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3. Provide circuit breakers in sizes, ratings, enclosures and accessories as indicated within Equipment Data Schedule or Disconnect Schedule located on the drawings, with interrupting capacity to comply with available fault currents.

B. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

C. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I^2t response.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install enclosed switches and circuit breakers in locations as indicated level and plumb, according to manufacturer's written instructions. Provide interconnection wiring for control and indication devices where applicable.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Install fuses in fusible disconnect switches such that label and rating information is readable without removing the fuse. Provide permanent label affixed to the inside of the disconnect switch cover indicating the fuse class and size installed.

3.03 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.04 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges per the Drawings.

3.05 CLEANING

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

END OF SECTION

SECTION 26 29 23
VARIABLE-FREQUENCY DRIVES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes AC Motor Variable Frequency Drives rated 600 V and less.

1.03 REFERENCES

A. ANSI/UL Standard 508.

B. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

C. IEEE Standard 519-1981 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters.

D. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference.

1.04 DEFINITIONS

A. BAS: Building automation system.

B. CPT: Control power transformer.

C. EMI: Electromagnetic interference.

D. IGBT: Insulated-gate bipolar transistor.

E. LAN: Local area network.

F. LED: Light-emitting diode.

G. MCP: Motor-circuit protector.

H. NC: Normally closed.

I. NO: Normally open.

J. OCPD: Overcurrent protective device.

K. PCC: Point of common coupling.

L. PID: Control action, proportional plus integral plus derivative.

M. PWM: Pulse-width modulated.

N. RFI: Radio-frequency interference.

O. TDD: Total demand (harmonic current) distortion.

P. THD(V): Total harmonic voltage demand.

Q. VFD: Variable-frequency drive.

1.05 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFD's shall withstand the effects of earthquake motions determined according to Specification section 13 05 41 Seismic Restraints.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device and remain fully operational when subjected to the seismic forces specified in Specification Section 13 05 41 Seismic Restraints.

1.06 SUBMITTALS

A. Submit shop drawing and product data in accordance with Conditions of Contract, Division 01 and Division 26 Specifications.

B. Product Data: Provide catalog sheets showing voltage, Drive size, ratings, and size of switching and overcurrent protective devices, short circuit ratings, dimensions and enclosure details.
   1. Shop Drawings: Include front and side views of enclosure with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
   2. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Factory-installed devices.
      c. Enclosure types and details.
      d. Nameplate legends.
      e. Short circuit current (withstand) rating of enclosed unit.
      f. Features, characteristics, ratings and factory settings of each VFC and installed devices.
   3. Schematic and Connection Wiring Diagrams: For power, signal and control wiring.

C. Manufacturer's installation instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation and starting of Product.

D. Seismic Qualification Certificates: For VFDs, accessories and components from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

1.07 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data in accordance with Conditions of Contract, Division 01 and Division 26 Specifications prior to final project closeout.

B. Operation and Maintenance Data: For VFDs to include in emergency, operation and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:
   1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
   2. Manufacturer's written instructions for setting field-adjustable overload relays.
   3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

C. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

D. Shop Drawings for each VFD.

1.08 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide VFD's from manufacturers regularly engaged in the manufacture of equipment of the types and capacities indicated, with such products in satisfactory use in similar service for not less than 5 years. Manufacturer shall maintain, within 100 miles of the project site, a service center capable of providing training, parts and emergency maintenance and repairs.

B. Single-source Responsibility: Obtain VFD's from a single manufacturer.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site in accordance with Conditions of Contract, Division 01 and Division 26 Specifications.

B. Accept drives on-site in original packing. Inspect for damage.

C. Store in a clean and dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect each drive from dirt, water, construction debris and traffic.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs approved for the purpose. Handle carefully to avoid damage.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURED UNITS

A. Manufacturers: Refer to Variable Frequency Drive schedule on drawings.

B. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2 and UL 508C.

C. Application: Variable torque.

D. VFD Description: Variable-Frequency Drive (rectifier, D.C. bus and IGBT, PWM inverter) factory-packaged in an enclosure with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency. No neutral conductor shall be used to supply the VFD.
   1. Units suitable for standard NEMA Design B squirrel cage 1.15 service factor induction motors without requiring any modifications to the motor or the drive.
   2. Minimum of six pulse operation.
   3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to Authorities Having Jurisdiction.

E. Features
   1. Display: Provide integral digital display to indicate all protection faults and drive status (including overcurrent, overvoltage, undervoltage, ground fault, over-temperature, phase loss, input power ON, output voltage, output frequency and output current.
   2. Protection:
      a. Input transient protection by means of surge suppressors.
      b. Snubber networks to protect against malfunctions due to system transients.
      c. Under- and over-voltage trips; inverter over-temperature, overload and overcurrent trips.
      d. Motor thermal overload relay(s) adjustable and capable of NEMA 250 and sized per motor nameplate data.
      e. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
      f. Instantaneous line-to-line and line-to-ground overcurrent trips on input and output.
      g. Loss-of-phase protection.
      h. Reverse-phase protection.
      i. Short-circuit protection (fuses or circuit breaker).

j. Motor over-temperature fault.

3. Acceleration Rate Adjustment: 0.5 to 30 seconds.
4. Deceleration Rate Adjustment: 1 to 30 seconds.
5. Minimum Adjustment Range for the Lower Output Frequency shall be: 0 to 40 Hertz.
6. Minimum Adjustment Range for the Upper Output Frequency Range shall be: 40 to 90 Hertz.
7. Minimum Volts/Hertz Range: 3.7 to 8.6 volts/Hertz.
8. Provide MANUAL-OFF-AUTOMATIC selector switch and manual analog speed control mounted on the front of the enclosure.
9. Safety Interlocks: Provide terminals for remote contact to inhibit starting under both manual and automatic mode.
10. Control Interlocks: Provide terminals for remote contact to allow starting in automatic mode.
11. Provide adjustable skip frequencies on the drive output (minimum of three ranges).
12. Automatic Reset/Restart: Attempt three restarts after controller fault or on return of power after an interruption, and before shutting down for manual reset or fault correction. Bi-directional auto speed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor or load.
13. Power-Interruption Protection: After a power interruption, it prevents the motor from re-energizing until the motor has stopped.
14. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
15. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
16. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
    a. Power on.
    b. Run.
    c. Overvoltage.
    d. Line fault.
    e. Overcurrent.
    f. External fault.
17. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
18. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
    a. Output frequency (Hz).
    b. Motor speed (rpm).
    c. Motor status (running, stop, fault).
    d. Motor current (amperes).
    e. Motor torque (percent).
    f. Fault or alarming status (code).
    g. PID feedback signal (percent).
    h. DC-link voltage (VDC).
    i. Set-point frequency (Hz).
    j. Motor output voltage (V).
19. Control Signal Interface:
    a. Electric Input Signal Interface: A minimum of two (2) analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

b. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   1) 0 to 10-V dc.
   2) 0-20 or 4-20 mA.
   3) Potentiometer using up/down digital inputs.
   4) Fixed frequencies using digital inputs.
   5) RS485.
   6) Keypad display for local hand operation.

c. Output Signal Interface:
   1) A minimum of one (1) analog output signal (0/4-20 mA), which can be programmed to any of the following:
      a) Output frequency (Hz).
      b) Output current (load).
      c) DC-link voltage (VDC).
      d) Motor torque (percent).
      e) Motor speed (rpm).
      f) Set-point frequency (Hz).

d. Remote Indication Interface: A minimum of two (2) dry circuit relay outputs (120-V a.c., 1A) for remote indication of the following:
   1) Motor running.
   2) Set-point speed reached.
   3) Fault and warning indication (over-temperature or overcurrent).
   4) PID high- or low-speed limits reached.

20. Communications: Provide a communications card to interface VFD with Building Automation System (BAS). Coordinate interface requirements with the BAS. Interface shall allow all parameter settings of VFD to be programmed via BAS control and displayed on BAS operator workstation. Provide capability for VFD to retain these settings within the nonvolatile memory.

21. Three-Contactor Manual Bypass:
    a. Provide contactors, motor running overload protection, under-voltage and loss of phase protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include isolation switch to allow maintenance of inverter during bypass operation.
    b. All bypass circuitry shall be located within the same enclosure as the variable frequency drive.
    c. All fire alarm and/or smoke control interconnections (e.g., air-handling unit shutdown) shall apply regardless of whether control is through VFD or bypass.
    d. Provide a Drive-Bypass Selector Switch.
    e. Provide nameplate with instructions for switching from drive-to-bypass and from bypass-to-drive.

22. Control:
    a. With the "Manual-Off-Auto" switch in the "Manual" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the manual speed potentiometer on the drive door.
    b. With the "Manual-Off-Auto" switch in the "Auto" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the input signal from an external source.
    c. If applicable, with the "Drive-Bypass" in the "Bypass" position, regardless the position of the "Manual-Off-Auto" switch, the motor shall be connected across the lines and shall be run at full speed.

d. With the "Manual-Off-Auto" switch in the "Off" position, if applicable, the drive run circuit shall be open and the VFD shall not operate.
e. If applicable, signal from the fire alarm control panel shall shut down VFD and bypass.
f. All disconnect switches between VFD and motor(s) shall include an auxiliary contact interlock wired to the VFD fault trip input to shut down the drive upon opening of the disconnect main contacts.

23. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.

F. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
1. Number of Loops: One.

2.02 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Provide input filtering, as required, to limit TDD and THD(V) at the defined PCC per IEEE 519.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports."

C. Floor-Mounting: Install VFDs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Division 26 Section “Hangers and Supports."

D. Roof-Mounting Controllers: Install VFD on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
1. Curbs and roof penetrations are specified in Division 07 Section "Roof Accessories."
2. Structural-steel channels are specified in Division 26 Section "Hangers and Supports."

E. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

G. Comply with NECA 1.

3.03 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFD with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to be present at start up and inspect, test, and adjust components, assemblies, and equipment installations, including connections.

3.05 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

END OF SECTION

SECTION 26 32 13
ENGINE GENERATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SEISMIC REQUIREMENTS

A. Conform to requirements in Section 13 05 41 "Seismic Restraints."

1.03 REFERENCES

A. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

B. ANSI/NEMA MG 1 - Motors and Generators.

C. ANSI/NFPA 70 - National Electrical Code.

D. ANSI/NEMA AB 1 - Molded Case Circuit Breakers.

E. NFPA 37 – Installation and Use of Stationary Combustion Engines and Gas Turbines.

F. NFPA 110 – Emergency and Standby Power Systems.

G. Environmental Protection Agency EPA Emission Standards for Compressed Ignition Engines. Tier 2

H. UL 2200 Listed

1.04 RELATED SECTIONS INCLUDE THE FOLLOWING

A. Section 26 36 00 “Transfer Switches” for transfer switches including sensors and relays to initiate automatic-starting and stopping signals for engine generator sets.

1.05 SYSTEM DESCRIPTION

A. Engine generator system to provide source of emergency and standby power.

B. System Capacity: 1000KW, 1250 KVA at an elevation of 1,000 feet above sea level, and ambient temperature between -20 degrees F and 110 degrees F; standby rating using engine-mounted radiator. Rated for US EPA Tier 2.

C. Operation: In accordance with ANSI/NFPA 99 Functional Description.

1.06 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 01 Specification Sections.

B. To be Submitted before Equipment Order:

1. Product data for products specified in this Section. Include data on features, components, ratings, and performance. Data shall include weights, fuel consumption rates, ventilation and combustion air requirements, exhaust flow data, cooling system data and engine and generator data. Include dimensioned outline plan and elevation drawings of engine generator set and other system components.
2. Shop Drawings: Detail fabrication, piping, wiring, and installation of the field-installed portions of the system. Include general arrangement drawings showing locations of auxiliary components in relation to the engine generator set and duct, piping, and wiring connections between the generator set and the auxiliary equipment. Show connections, mounting, and support provisions and access and working space requirements. Submit all pertinent construction details for weatherproof enclosures.
3. Wiring Diagrams for System: Show power and control connections and distinguish between factory-installed and field-installed wiring. Terminals for field wiring the system

controls and between equipment shall be labeled in a consistent point to point manner by the manufacturer.

C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, weatherproof enclosure and components will withstand seismic forces defined in Section 13 05 41 “Seismic Restraints." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Certified Summary of Prototype Unit Test Report: Submit certified copies of actual prototype unit test report.

E. Submit certificates for compliance with EPA Emissions Standards for Compressed Ignition Engines.

F. Certification of Torsional Vibration Compatibility: Conform to NFPA 110.

G. To be Submitted After Equipment Order:
   1. Factory Test Reports: Provide for units to be shipped for this Project showing evidence of compliance with specified factory test requirements.
   2. Maintenance data for system and components for inclusion in Operating and Maintenance Manual specified in Division 01. Include the following:
      a. Lists: Tools, test equipment, spare parts, and replacement items. Include part and drawing numbers, current unit prices, and source of supply.
      b. Detailed Operating Instructions: Cover operation under both normal and abnormal conditions.

H. Field Test Report: Record of tests specified in Part 3.

1.07 WARRANTY

A. The complete electrical power system (generator, weatherproof enclosure, engine, controls, associated switchgear and accessories) shall be warranted by the manufacturer against defects in materials and workmanship for a period of two years from the date of Substantial Completion. Coverage shall include parts, travel expenses and labor to remove and install the necessary parts and equipment.

1.08 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months’ full maintenance by skilled employees of the manufacturer’s designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.09 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms experienced in manufacturing equipment of the types and capacities indicated that have a record of successful in-service performance.

B. Manufacturer’s Service Personnel: Service personnel shall be factory trained and certified in the maintenance of the specified equipment.

1. Emergency Service: System manufacturer shall maintain a service center capable of providing training, parts, and emergency maintenance and repairs at the Project site within a time period of less than 4 hours from time of notification, 365 days per year.

C. Electrical Items and Components shall be listed (or recognized) by Underwriters Laboratories, Inc.

D. Non-Electrical Components shall be listed (or recognized) by Underwriters Laboratories, Inc. or other applicable Nationally Recognized Testing Laboratory.

E. Engine Exhaust Emissions: Comply with applicable Federal, State, and local government requirements.

F. Single-Source Responsibility: Unit shall be a representative product built from components that have proven compatibility and reliability and are coordinated to operate as a unit as evidenced by records of prototype testing.

1.10 NOISE EMISSION

A. Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

1.12 EXTRA MATERIALS

A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to the Owner.
   1. Fuses: 1 for every 10 of each type and rating, but not less than 2 of each.
   2. Pilot Lights: 1 for every 3 of each type used, but not less than 2 of each.
   3. Filters: 1 set each of lubricating oil, fuel, and combustion air filters.

1.13 COORDINATION

A. Coordinate size and location of concrete bases for engine generators. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Provide generator electronic CAD drawings to Coordinating Contractor for inclusion into composite coordination drawings. Show generator, fuel system components, battery system components, and exhaust system in 1/4 inch scale plan of room.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Engine Generator Set Manufacturers: Subject to compliance with requirements, provide completely assembled engine-generator units by one of the following engine generator set manufacturers:
   1. Caterpillar, Inc.
   2. Cummins Power Generation.
   3. Kohler Company.
   4. MTU On Site Energy.

2.02 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Fabricate engine-generator set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.

C. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components.

2.03 SYSTEM SERVICE CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: Minus 20 degrees F to plus 120 degrees F.
   2. Relative Humidity: 0 to 95 percent.
   3. Altitude: Sea level to 1000 feet.

2.04 ENGINE

A. Type: Water-cooled in-line or V-type, compression ignition diesel electric ignition internal combustion engine.

B. Rating: Sufficient to operate at 100 percent load for two hours at specified elevation and ambient limits.

C. Fuel: No. 2 fuel oil.

D. Rated Engine Speed: 1800 rpm.

E. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

F. Engine Fuel System:
   1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
   2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

G. Engine Fuel Supply System: Comply with UL 142 fuel oil tank.
   1. Day Tank: UL listed fuel tank with capacity as indicated on drawings. Integral rupture basin with 150 percent of nominal capacity and leak detection. Dual integral self-priming pumps and level control with indication. Low-level sensor at 25 percent with alarm and contacts. High-level sensor with alarm, contacts, and redundant fuel shutoff. Include flexible fuel line connections for all supply and return lines. Provide with emergency vent cap.
   2. Base-Mounted Fuel Tank: UL listed fuel tank with capacity (24 hours of operation at full nameplate capacity) as indicated on drawings. Integral rupture basin with leak detection. Provide fueling port with an overfill prevention type receptacle and lockable cap for exterior units. The tank shall include structural steel supports for top mounted engine generator set. Furnish complete with flexible fuel line connectors lockable cover, and analog level gauge. Furnish complete with float switches to indicate low fuel level 5 percent,25 percent, 50 percent and 75 percent. The footprint of the base-mounted fuel tank shall not exceed the footprint of the generator frame for interior applications or the footprint of the enclosure for exterior installations.

H. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90 degrees F, and suitable for operation on 120volts AC. The minimum wattage of the heater shall be as recommended by the manufacturer.

I. Governor: Adjustable isochronous, with speed sensing.

J. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Non-ferrous metal construction sized to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

K. Muffler/Silencer: Sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   1. Critical Type:
      a. Minimum sound attenuation of 25 dB at 500 Hz.
      b. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

L. Air-Intake Filter: Heavy-Duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

M. Starting System: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel. Provide the following accessories:
   1. Battery: Voltage to match starter and cranking cycle of three times without recharging. Provide with acid resistant battery tray.
   2. Battery Cable: Size as recommended by engine manufacturer. Include required interconnecting conductors and connection accessories.
   3. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
   4. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
      a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
      b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 degrees C to plus 60 degrees C to prevent overcharging at high temperatures and undercharging at low temperatures.
      c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
      d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
      e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
      f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.05 ENGINE GENERATOR SYSTEM

A. General: System shall be a coordinated assembly of compatible components.

B. Ratings: Voltage and frequency ratings of the system shall be as indicated on the drawings. Standby power rating of the engine-generator system shall be as indicated on the drawings per manufacturer. Generator shall be rated at a 0.80 lagging to 0.80 leading power factor.

C. System Output Configuration: 3 phase, 4 wire.

D. The generator will be a separately derived system. Separate grounding of the generator neutral at the generator will be required.

E. Safety Standard: Comply with ASME B15.1, "Safety Standard for Mechanical Power Transmission Apparatus."

F. Nameplates: Each major system component shall be equipped with a conspicuous nameplate of the component manufacturer. Nameplate shall identify manufacturer of origin and address, the model and serial number of the item, and factory order number.

G. Resistance to Seismic Forces: Internal and external supports for components, supports, and fastenings for batteries, wiring, and piping shall be designed to withstand both static and anticipated seismic forces in any direction. Use a minimum force values in accordance with Section 13 05 41 "Seismic Restraints."

2.06 SYSTEM PERFORMANCE

A. Steady-State Voltage Operational Bandwidth: Shall not exceed 4 percent of nominal rated output voltage from no load to full load. The frequency of cyclical variations shall be less than one hertz.

B. Transient Voltage Performance: Not more than 13 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 3 seconds.

C. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

D. Steady-State Frequency Stability: When the system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no regular or cyclical hunting or surging of speed.

E. Transient Frequency Performance: Less than 3 Hz variation for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 5 seconds.

F. Output Waveform: At no load, the voltage harmonic content measured line-to-line or line-to-neutral shall not exceed 5 percent total and 3 percent for single harmonics. The telephone influence factor determined according to NEMA MG1, "Motors and Generators," shall not exceed 50.

G. Sustained Short-Circuit Current: For a 3-phase bolted short circuit at the system output terminals, the system shall supply a minimum of 250 percent of rated full-load current for 10 seconds.

H. Temperature Rise: 80 degrees C continuous.

I. Nonlinear Load Performance: System performance shall not be degraded from that specified in this Section by continuous operation, with the load current having a minimum total harmonic content of 25 percent RMS, and minimum 10 percent RMS single harmonic content for any of the 3rd, 5th, 7th, 9th, or 11th harmonics.

J. Starting Time: Comply with NFPA 110, Type 10, system requirements. Maximum total time period for a cold start, with ambient temperature at the low end of the specified range, shall be 8 seconds. Time period includes output voltage and frequency settlement within specified steady-state bands.

K. Block Load: Engine generator shall be capable of accepting a 75 percent block load at 0.80 lagging power factor at the ambient conditions specified above without exceeding a 20 percent voltage dip.

2.07 ENGINE GENERATOR SET

A. Power Output Rating: Nominal ratings as indicated per manufacturer on the drawings, with capacity as required to operate as a unit as evidenced by records of prototype testing.

B. Skid: Heavy duty steel base to maintain alignment of the mounted components without dependence on a concrete foundation. Skid shall be free from sharp edges and corners. Lifting attachments shall be arranged to facilitate lifting with slings without damaging any components.

2.08 CONTROL AND MONITORING

A. Configuration: Operating and safety indications, protective devices, engine gages, basic system controls, and other indicated components shall be grouped in a combination control and power panel. Panel shall be mounted on the generator set unless otherwise indicated. Control and monitoring section of panel shall be isolated from power sections by steel barriers.

B. Ground Fault: Provide ground fault sensing at the generator. The sensor shall be located ahead of the generator service disconnect. Provide a ground fault indication on the engine-generator control panel. Provide an instruction nameplate at the control panel.
   1. Instruction nameplate: Provide operational instructions for a ground fault indication as approved by the local Authority Having Jurisdiction.

2.09 GENERATOR CIRCUIT BREAKER: MOLDED OR INSULATED CASE, SERVICE-RATED WITH ADJUSTABLE LSI ELECTRONIC TRIP TYPE; 100 PERCENT RATED BREAKER COMPLYING WITH NEMA AB1 AND UL 489

A. Tripping Characteristic: Designed specifically for generator protection.

B. Trip Rating: Matched to generator rating.

C. Shunt Trip: Connected to trip breaker when generator is shut down by other protective devices.

D. Mounting: Provide freestanding enclosure or mount integrally with control and monitoring panel.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator circuit breaker shall open the circuit breaker to disconnect the generator from load circuits. Protector shall perform the following functions:
   1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
   2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
   3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator circuit breaker, and shuts down the generator set.
   4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

F. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

G. Indicating Devices, Protective Devices, and Controls: Common Audible with Individual Visible Alarm to conform to NFPA 110 requirements for Level 1systems.

H. Include necessary Form C contacts and terminals in control and monitoring panel. Include those required by NFPA 110 for a Level 1 system plus the following:
   1. A.C. Voltmeter.
   2. A.C. Ammeter.
   3. A.C. Frequency Meter.
   4. D.C. Voltmeter (Alternator Battery Charging).
   5. Engine Coolant Temperature Gage.
   6. Low Engine Coolant Temperature Indicator Lights.
   7. Engine-Lubricating Oil Pressure Gage.
   8. Running Time Meter.
   9. 4 position Ammeter Phase Selector Switch.
   10. Auxiliary Contacts: Separate terminal blocks factory wired to separate form C dry contacts. Contacts shall be for field connection and to start generator ventilation fans and motorized dampers. Contacts shall activate upon generator start signal. Provide two Form A and two Form B contacts, each rated no less than 10 amperes at 120 volts AC and no less than 5 amperes at 24 volts DC.
   11. Generator Voltage-Adjusting Control.
   12. Fuel tank derangement alarm.
   13. Fuel tank high level shutdown of fuel supply alarm.
   14. Generator overload.
   15. Supporting Items: Include sensors, transducers, terminals, relays, and other devices, and wiring required to support specified items. Locate sensors and other supporting items in engine generator control panel unless otherwise indicated.
   16. Temperature Relay: Provide temperature relay(s) as required at generator to monitor bearing and stator windings. Provide minimum of two contacts (form C) for each of alarm and shutdown. Factory wire shutdown output contacts to generator control panel. Temperature relay may be omitted if the generator control panel can perform the same monitoring and output contact functions.

2.10 LOCAL AND REMOTE ALARMS AND SHUTDOWN

A. Conform to NFPA 110 requirements for Level 1 systems. Include necessary Form C contacts and terminals in control and monitoring panel.

B. Local Alarms: Provide generator set mounted alarms as follows with shutdown where noted:
   1. Over-crank (with shutdown).
   2. Over-speed (with shutdown).
   3. Low lube oil pressure (with shutdown).
   4. High engine temperature pre-alarm.
   5. High engine temperature (with shutdown).
   6. Low fuel main tank.
   7. Generator supplying load.
   8. Low water temperature.
   9. Control switch not in auto.
   10. High battery voltage.
   11. Low battery voltage.
   12. Battery charger A.C. failure.
   13. Storage tank leak.
   14. Low coolant level.
   15. Low cranking voltage.

C. The above alarms shall be by individually identified visual indications plus a common audible alarm.

D. There shall be a lamp test switch to test all of the above lamps.

E. The remote emergency stop switch shall also shut the unit down.

F. Remote Alarms:
   1. Provide a remote generator alarm annunciator for the generator powered from the generator battery, with an individually identified visual indication for any of the following conditions:
      a. Over-crank (with shutdown).
      b. Over-speed (with shutdown).
      c. Low lube oil pressure (with shutdown).
      d. High engine temperature pre-alarm.
      e. High engine temperature (with shutdown).
      f. Low fuel main tank.
      g. Low water temperature.
      h. Control switch not in auto.
      i. High battery voltage.
      j. Low battery voltage.
      k. Battery charger A.C. failure.
      l. Storage tank leak.
      m. Low coolant level.
      n. Low cranking voltage.
   2. In addition, a common audible alarm shall sound at the remote annunciator when any of the conditions above is activated. The audible alarm shall be silence able, but must have a resound feature which will require the restoration of the silence switch to its normal position when the alarm condition has been corrected.
   3. The remote annunciator shall also include a lamp test switch.

G. Remote Emergency Stop Switch: Wall-mounted red 2-1/4 inch jumbo mushroom head pushbutton type similar to Allen-Bradley Bulletin 800H with 800T-N247R head. Pushbutton shall be protected from accidental operation with clear cover. The manufacturer shall provide automatic monitoring of the emergency stop switch. Placing this switch in the “Generator Powered Off” status shall initiate a visual and audible alarm at each generator annunciator panel. Provide lamacoid nameplate reading: "Generator Emergency Shutdown."

H. Connection to Building Automation System: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication. Provide individual terminal points for each of the annunciator alarms and pre-alarms. Provide an additional terminal point to combine all of the generator alarms under a single terminal point. Provide a permanent label for each terminal point. Each terminal will provide a binary output for the building automation system to read.

2.11 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1, "Motors and Generators," and specified performance requirements.

B. Rating: As indicated on the drawings, at 0.8 power factor, 60 Hertz at RPM to match engine rating.

C. Electrical Insulation: All windings shall be Class H insulation applied under a vacuum pressure impregnation (VPI) cycle.

D. Temperature Rise:80 degrees C continuous.

E. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

F. The AC generator shall be re-connectible brushless synchronous, four pole generator with brushless exciter and PMG alternator excitation.

G. Enclosure: ANSI/NEMA MG1, open drip-proof.

H. A permanent magnet generator (PMG) shall provide excitation power to the automatic voltage regulator for immunity from voltage distortion caused by non-linear SCR controlled loads on the generator. The PMG shall sustain main field excitation power for optimum motor starting and to sustain short circuit current as described above under "System Performance."

I. The automatic voltage regulator shall be temperature compensated solid-state design. The voltage regulator shall be equipped with three-phase RMS sensing. The regulator shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. Overvoltage protection shall sense the AC generator output voltage and in the event of regulator failure or loss of reference, shut down regulator output on a sustained overvoltage of one (1) second duration. Overexcitation protection shall sense regulator output and shut down regulator output if overloads exceed ten (10) seconds duration. Both overvoltage and overexcitation protection shutdowns shall be latched, requiring the AC generator to be stopped for reset.
   1. The maximum voltage drop shall be [28] [30] percent.
   2. Voltage regulation +/-1 percent from no load to full load. Include manual controls to adjust voltage drop +/-5 percent voltage level, and voltage gain.

J. The regulator shall include an under frequency rolloff torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of 58-59 HZ. The torque-matching characteristic shall include differential rate of frequency change compensation to use maximum available engine torque and provide optimal transient load response. Regulators which use a fixed volts-per-hertz characteristic are not acceptable.

K. Sub-transient Reactance (X'd): Maximum 15 percent.

L. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

2.12 OUTDOOR GENERATOR SET ENCLOSURE

A. Provide a prefabricated or pre-engineered sound attenuating weatherproof enclosure over unit with the following features:
   1. Construction: Reinforced galvanized-steel, metal-clad, integral structural-steel-framed building anchored to a concrete foundation. Structural design and anchorage to comply with ASCE 7 for wind loads up to 100 mph.
   2. Hinged doors on opposite sides with cylinder type locks keyed alike.
   3. Mount control panel and circuit breaker on inside of housing in such a fashion as to enable opening of the disconnect door and easy access.
   4. Provide louvers in sides and end to allow for engine and generator cooling with screen and filters to allow proper air flow while at the same time preventing dust, bird and rodent entry.
   5. Muffler shall be mounted within the enclosure.
   6. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits as required by engine-generator-set components.
   7. Fuel Tank Vent: Provide vent piping from the fuel tank to the exterior of the enclosure.
   8. Fuel Fill: Provide fill access on the exterior of the enclosure at an elevation not to exceed 5 feet-0 inches above finished grade.
   9. Acoustical Treatment: Provide sound attenuating acoustical treatment of the generator enclosure including wall panels, intake and exhaust air paths, ventilation openings, and tailpipe exhaust.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

2.13 VIBRATION ISOLATION DEVICES

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.14 PROTOTYPE TESTING

A. Performed on a separate engine generator set at 80 percent lagging power factor using the same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
   1. Load bank test using full load at 80 percent p.f. for 30 minutes.

B. Tests: Conform to those required for Level 1 energy converters in NFPA 110.

C. Seismic Shock Test per NFPA 110.
   1. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype shall have been acceptably tested to demonstrate compatibility and reliability.
   2. Submit evidence of torsional vibration capability in accord with NFPA.
   3. Submit the above with shop drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Anchor the generator set on concrete slab or on separate concrete base for outdoor units. Comply with Division 03 for concrete, Division 13 for seismic anchoring and to manufacturer’s recommendations.

B. Maintain minimum working space around components according to NEC Article 110.

C. The A-B-C phase rotation of the generator source shall match the A-B-C phase rotation of the utility source. The Contractor shall verify the generator and utility phase rotation match to prevent three phase motors and similar loads from operating backwards while being served by the generator.

D. Install remote manual emergency stop switch in location shown on plans. Provide 120 Volt power and wiring in conduit as required. Coordinate installation with the manufacturer approved shop drawings and wiring diagrams. The remote manual stop station shall shunt trip the generator mounted circuit breaker and signal the engine prime mover to stop.

E. Manufacturer's Field Services: Arrange and pay for the services of a factory-authorized service representative to supervise the installing, connecting, testing, and adjusting of the unit at its permanent location.

3.02 FIELD QUALITY CONTROL

A. Project Specific Tests:
   1. Supervised Adjusting and Pretesting: Under supervision of factory-authorized service representative, pretest all system functions, operations, and protective features. Provide all instruments and equipment required for tests. Adjust to ensure operation is according to Specifications. Load system using a variable resistive load bank simulating full load rating of unit.

2. Field Acceptance Tests: Provide the acceptance tests required by NFPA 110, in addition to the tests listed below. Provide the services of a qualified independent testing organization to perform all tests. All tests shall be run with manufacturer's representative present and upon completion of installation of the system. Use instruments bearing records of calibration within the last 12 months, traceable to NIST standards, and adequate for making positive observation of test results. Provide written report tabulating all individual tests and their respective results. Include the following tests:
3. Insulation Tests: Test generator windings using 500 V D.C. for units rated up to 250 volts and 1000V D.C. for units rated between 250 and 600 volts. Verify minimum insulation resistance is 25 megohms for units up to 250 volts and 100 megohms for units between 250 and 600 volts.
4. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify measurements are within manufacturer's specifications.
5. Battery Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
7. Simulation of malfunctions to verify proper operation of local and remote protective, alarm, and monitoring devices.
8. Load Test: Use variable resistive load bank capable of simulating kW for which unit is rated. Run unit at 25, 50, and 75 percent of rated capacity for 15 minutes each, and at 100 percent for 4 hours. Record voltage, frequency, load current, battery-charging current, power output, oil pressure, and coolant temperature periodically during the test. Provide all necessary cable lengths and connections as required.
9. Hydrostatic Test: Perform on radiator, heat exchanger, and engine water jacket.
10. Voltage and Frequency Transient Stability Tests: Provide chart recorder to measure voltage, current and frequency transients for 50-percent and 75-percent step-load increases and decreases to verify that performance is as specified in the “System Performance” of this specification.
11. Vibration Baseline Test: Measure amplitude for nominal frequency and for frequencies 5, 10, 15, and 20 percent above and below nominal at each main bearing cap. Vibration levels not exceeding those specified in NEMA MG1, "Motors and Generators," are acceptable. This test is only required in the field when it is necessary to disassemble and re-assemble the engine generator unit after it has been vibration baseline tested at the factory.
12. Exhaust System Back-Pressure Test: Use a manometer with a scale exceeding 40 inches of water. Connect to the exhaust line close to the engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's published allowable limits for the engine.
13. The following continuous and simultaneous straight-line recordings versus time, shall be made at a chart speed of no less than fifty millimeters per second. The recorder shall run from at least ten seconds before the test event and until at least ten seconds after the test event.

Phase A RMS current.	Phase A to N RMS voltage.
Phase B RMS current.	Phase B to N RMS voltage.
Phase C RMS current.	Phase C to N RMS voltage.

14. The following simultaneous actual wave shape recordings versus time, shall be made at a chart speed of no less than 200 millimeters per second. The chart recorder shall run from at least five seconds before the test event to at least five seconds after the test event. These recordings do not have to be run at the same time as the above recordings.

    Phase A to neutral voltage. Phase A current.
    Phase B to neutral voltage. Phase B current.
    Phase C to neutral voltage. Phase C current.

15. Analyzers which indicate only the maximum and minimum values of frequency, current and voltage are not acceptable. In addition to the above recordings, analyzer shall also have digital readout of each input channel, and battery back-up. Provide straight line recordings and wave shape recording. Provide all necessary current transformers, amplifier racks, and other accessories for complete testing. Current transformer primary shall be as close to the generator full load current as possible, without causing saturation of the current transformer or saturation or overload of the analyzer or signal conditioning circuits.
16. A Dranetz-BMI Model #PX5 power analyzer or equivalent. Include 128m Flash Care and "Enterprise" Version software to provide hard copy printouts of measured values. Unit shall have adequate internal storage capacity for all required printouts of test data via a USB port. An alternative rental agency is TRS-REN (1-800-621-6354) or Continental Resources at 1-800-937-4688 or General Electric at 1-800-GE-RENTS. The technical representative for the PX5 is Ed Russo at 1-800-372-6832.
17. All of the above testing shall be scheduled with the Owner and Engineer. Submit test results to Engineer within two weeks of testing.
18. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
19. In addition, manufacturer shall submit written verification that unit complies with NFPA 110 and that unit performs satisfactorily after installation.

3.03 CONNECTIONS

A. Conduit Connections: All power and control wiring connections to the generator control panel and electrical accessories shall be made with a minimum of 18 inch Liquidtight steel conduit.

3.04 DEMONSTRATION

A. Training: Arrange and pay for the services of a factory-authorized service representative to demonstrate adjustment, operation, and maintenance of the system and to train Owner's personnel.

B. Conduct a minimum of 8 hours of training as specified under Instructions to Owner's Employees in the “Project Closeout” section of these Specifications.

C. Schedule training with at least 7-day advance notice.

3.05 DOCUMENTATION REQUIREMENTS

A. A complete set of "Operations and Maintenance Manuals" shall be furnished for the generator system, including the following:
    1. Equipment outline, showing front and side plan views, electrical power one-line diagram, conduit entrances, and equipment ratings.
    2. Schematic drawings.
    3. Wiring diagrams.
    4. Interconnection wiring diagram, showing all field interconnections among generator sets, circuit breakers and relays, and other remote devices, battery charger and all fuel tanks.
    5. Materials list, cross-referenced to schematics for component identification.
    6. Narrative sequence of operation description, detailing all possible operating modes.

7. Ladder diagram and program listing for programmable controller with each logic rung purpose clearly defined, including identification of inputs and outputs.
8. Test Data per Factory and Field Testing.
9. All equipment drawings shall specifically show the interface between the generator, control and monitoring equipment, and remote devices. Standard or typical drawings are not acceptable.

B. Provide one set each of complete documents to the Engineer and Owner in three-ring binders. This is in addition to submittal requirements of Division 01.

3.06 IDENTIFICATION

A. Identify system components according to Division 26 Section "Electrical Identification."

B. Install permanent sign at building's utility power service disconnect indicating the type and location of the emergency power source.

3.07 CLEANING

A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

END OF SECTION

SECTION 26 36 00
TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:
   1. Automatic transfer switches.
   2. Bypass/isolation switches.
   3. Remote annunciation systems.

1.03 REFERENCES

A. NEMA ICS 1 - General Standards for Industrial Control and Systems

B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies

C. NEMA ICS 6 – Enclosures for Industrial Controls and Systems

D. NEMA ICS 10 - AC Automatic Transfer Switches

E. UL 1008 – Standard for Automatic Transfer Switches

1.04 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 01 Specification Sections.
   1. Shop drawings or published product data for each transfer switch, including dimensioned plans, sections, and elevations showing minimum clearances; conductor entry provisions; gutter space; installed features and devices, wiring diagrams, materials lists.
      a. Where the short-circuit current rating of the transfer switch is dependent on the upstream overcurrent protective device, submit manufacturer published literature indicating tested overcurrent protective devices and the resultant short-circuit current rating of the transfer switch. Indicate the applicable rating for the submitted transfer switch based on actual overcurrent protective device being provided as part of the related shop drawings.
   2. Manufacturer’s installation instructions.

B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 13 Section "Seismic Restraints." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in automatic transfer equipment with minimum three (3) years documented experience.

B. Source Limitations: Obtain transfer switches, remote panels and accessories through one source from a single manufacturer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ASCO Power Technologies, LP.
2. GE Zenith Controls.
3. Russelelectric, Inc.

B. When specification 26 32 13 “Engine Generators” is included, transfer switches manufactured by the engine generator manufacturer are allowed only when provided in conjunction with a new engine generator set as part of this scope of work. Refer to specification section 26 32 13 “Engine Generators” for approved manufacturer list.

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Provide transfer switches with number of poles, voltage and current ratings and accessories as shown on drawings.

B. Transfer switches shall be electrically operated and mechanically held.

C. The electrical operator shall be a solenoid mechanism, momentarily energized to minimize power consumption and heat generation.

D. Transfer switches shall include both electrical and mechanical interlocks to prevent both sets of main contacts from being closed at the same time.

E. Transfer switches shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized.

F. Transfer switches shall be provided with a microprocessor control panel and a door-mounted display panel for user interface.

G. Inspection of all contacts shall be possible from the front of the switch, without disassembly of operating linkages and without disconnection of power conductors.

H. Transfer switches shall be capable of handling continuous-duty repetitive transfer of full-rated current between active power sources.

I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

2.03 RATINGS

A. Available interrupting capacity (AIC) rating for each transfer switch shall meet or exceed the values listed within the drawings.
   1. Series rating with upstream devices shall be allowed per UL-1008.
   2. The required series rating shall be the larger of the two AIC values when the AIC rating of the equipment feeding the normal and emergency sides of the transfer switch is not equivalent.

2.04 AUTOMATIC TRANSFER SWITCHES

A. Transition type: Open, unless otherwise specifically indicated on drawings.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Automatic transfer switch shall be capable of manual operation under load with the door closed with either or both sources energized. Transfer time shall be the same as for electrical operation. The control circuit shall automatically disconnect from the electrical operator during manual operation.

D. Automatic Transfer-Switch Sequence of Operation:
   1. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.
   2. Time Delay to Start Alternate Source Engine Generator: Zero (0) to ten (10) seconds, adjustable.
   3. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.
   4. Time Delay Before Transfer to Alternate Power Source: Zero (0) to thirty (30) seconds, adjustable.
   5. Initiate Retransfer Load to Normal Source: Upon permission by normal source monitor.
   6. Time Delay Before Transfer to Normal Source: Zero (0) to thirty (30) minutes, adjustable. Bypass shall have a time delay in the event of an alternate source failure.
   7. Time Delay Before Engine Shut Down: Zero (0) to thirty (30) minutes, adjustable. Time delay shall begin when generator is unloaded.

2.05 BYPASS/ISOLATION SWITCHES

A. Description: Manual type, two-way switch arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. The bypass/isolation switch shall have the same phase arrangement and number of poles as the ATS. Current, voltage, closing, and short-circuit withstand ratings shall be equal to or greater than that of the associated ATS.

B. Bypass to the load-carrying source shall be accomplished with no interruption of power to the load.

C. When the isolation switch is in the “Test” or “Open” position, the bypass switch shall function as a manual transfer switch.

D. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
   1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
   2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.

3. Indicating lights: LED indicators confirming the bypass/isolation switch position status (e.g., Bypassed to Normal, Bypassed to Emergency, Test and Open)
4. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
5. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

E. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

F. Control Panel Power: When bypass/isolation switch is in the “Test” position, the control panel shall remain energized by the connected source to allow for electrical operation of the transfer switch.

2.06 SERVICE ENTRANCE RATED TRANSFER SWITCH

A. Description: Automatic or manual type as previously specified, combination transfer switch, service disconnecting means and overcurrent protective device with grounding and bonding requirements within a single enclosure, service entrance rated.

B. Overcurrent Protection Device: Normal connection shall be provided with a thermal magnetic, three-pole, molded case circuit breaker with current ratings shown on plans.

2.07 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Switch position.
3. Switch in test mode.
4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated. Refer to floor plans for installation locations. Extend conduit and wiring as required by manufacturer to each location.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.08 REQUIRED ACCESSORIES FOR ALL TRANSFER SWITCHES

A. In-Phase Monitor: Provide factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

B. Indicating Lights: Provide indicating lights mounted in cover of enclosure to indicate the following:
1. Normal Source Available.
2. Alternate Source Available.
3. Switch Position.

C. Return to Normal Switch: Provide switch mounted in cover of enclosure to initiate manual transfer from alternate to normal source.

D. Source Monitor: Provide source monitor for each line of the normal and alternate source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 Hertz from rated nominal value. Threshold values shall be field adjustable.

E. Test Switch: Provide switch mounted in cover of enclosure to simulate failure of normal source.

F. Transfer Switch Auxiliary Contacts: Provide the following isolated dry contacts to indicate the following conditions:
   1. Normal source is available.
   2. Emergency source is available.
   3. Transfer switch position connected to normal source.
   4. Transfer switch position connected to emergency source.

G. Facility Management Control System Interface: Provide auxiliary contacts, prewired to an accessible terminal strip.

2.09 OPTIONAL ACCESSORIES

A. Refer to Transfer Switch Schedule on drawings for requested optional accessories.

B. Engine Exerciser: Provide an integral engine exerciser to automatically test the engine generator set with or without load on a set schedule and duration. Parameters associated with start time (day, week, month), frequency and duration of test shall be fully programmable.
   1. Provide integral battery operation of time switch when normal control power is not available.

C. Elevator Emergency to Normal Pre-signal: Provide selective load disconnect control contacts capable of sending a pre-transfer and post-transfer signal to disconnect elevator controls prior to transfer and reset after transfer is complete. Contacts shall have an adjustable advance interval of 0.5 to 60 seconds and shall be independently adjustable in the emergency and normal transfer directions.

D. Strip Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

E. Communications Interface: Provide serial and Ethernet communication module for interface with building automation system.

F. Power Monitoring: Provide a microprocessor-based power monitor with user interface to record and display the following parameters:
   1. Voltage (line-to-line and line-to-neutral).
   2. Frequency.
   3. Current.
   4. Real and reactive power.
   5. Power factor.

G. Load Shed Feature: Provide controller circuit such that operation of a remote contact or voltage signal connected to the transfer switch controller initiates transfer of the connected load back to the normal source or to a center off position regardless of the source availability.

H. Surge Protection: Provide integral surge protection device providing load side protection. Provide protection for each phase and neutral (where utilized). Coordinate system voltage configuration with drawings.

I. Transfer Inhibit: Provide a remote means to inhibit power transfer in either direction.

2.10 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.11 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 13 Section “Seismic Restraints.”

B. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Concrete Bases: Do not provide concrete bases for bypass isolation transfer switches.

C. Identify components according to Division 26 Section "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Provide wiring to elevator controller for emergency source mode and emergency to normal pre-signal.

F. Provide self-adhesive vinyl label indicating the short circuit current rating of the transfer switch based on overcurrent protective device type and settings. Label shall be installed on the exterior of the transfer switch.

3.02 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
   2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
      a. Check for electrical continuity of circuits and for short circuits.
      b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
      c. Verify that manual transfer warnings are properly placed.
      d. Perform manual transfer operation.
   5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      b. Simulate loss of phase-to-ground voltage for each phase of normal source.
      c. Verify time-delay settings.
      d. Verify pickup and dropout voltages by data readout or inspection of control settings.

e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

B. Coordinate tests with tests of generator and run them concurrently.

C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

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

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training." Provide a minimum of four (4) hours of instruction scheduled seven days in advance.

B. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 26 41 13
LIGHTNING PROTECTION SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Section 26 05 26 "Grounding and Bonding."

1.02 SUMMARY

A. Section includes:
   1. Lightning protection for structure(s).
   2. Grounding and bonding for lightning protection.

B. System Description:
   1. Lightning Protection System: System protecting the indicated structure, consisting of air terminals on roofs, roof-mounted mechanical equipment, chimneys and stacks, and parapets; bonding of structure and other metal objects; grounding electrodes; and interconnecting conductors. Class I materials shall be used for systems on structures not exceeding 75 feet in height.
   2. Performance Statement: This specification and the accompanying roof plan(s) describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every air terminal, conductor, and connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all equipment and wiring required for a complete and operational system.

1.03 REFERENCES

A. ANSI/NFPA 780 - Lightning Protection Code

B. ANSI/UL 96 - Lightning Protection Components

C. LPI-175 - Lightning Protection Institute Installation Standard

D. LPI-176 - Lightning Protection Institute System Material and Components Standards

E. UL 96A - Installation Requirements for Lightning Protection Systems

1.04 SUBMITTALS

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

B. Shop Drawings: For air terminals and mounting accessories.
   1. Layout of the lightning protection system, along with details of the components to be used in the installation.
   2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
   3. Qualification Data: For qualified Installer and manufacturer, include data on listing or certification by UL.
   4. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material and lightning protection system.

C. Field quality-control inspection reports indicating compliance with specified requirements.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Authorized installer of manufacturer with minimum three (3) years' experience.

B. System Certificate:
   1. UL Master Label.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.06 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate the work of this Section with the exterior and interior finish installations. Coordinate painting of exposed conduits to match building finish with Architect.

C. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

D. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

E. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ERICO International Corporation.
   2. Heary Brothers Lightning Protection Co. Inc.
   3. Thompson Lightning Protection.
   4. Harger.
   5. Robbins Lightning Inc.

2.2 MATERIALS

A. All materials shall be copper and/or copper-bronze. In locations where the system components are mounted on aluminum surfaces, aluminum materials shall be used to avoid electrolytic corrosion of dissimilar metals.

B. All components shall be in accordance with ANSI/UL 96 or nationally recognized testing laboratory.

C. Air Terminals: Tubular with brace attached to the terminal at not less than half the height of the terminal. Provide terminals with sphere 3/4 inch safety tip. Provide swivel brackets to plum air terminals when mounting on sloping surfaces.

D. Main and Bonding Conductors: Copper.

E. Ground Rods: Copper-clad steel; 3/4 inch in diameter by 10 feet long.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install lightning protection components and systems according to UL 96A and NFPA 780.

C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.

D. Conceal the following conductors:
   1. System conductors.
   2. Down conductors.
   3. Interior conductors.
   4. Notify Architect/Engineer a minimum of 48 hours in advance for inspection before concealing lightning protection conductors.

E. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
   1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.

F. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

G. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

3.02 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

C. Bi-metal transition fittings shall be used when changing between aluminum and copper conductors.

3.03 FIELD QUALITY CONTROL

A. Obtain the services of Underwriters’ Laboratories, Inc. to provide inspection and certification of the lightning protection system under provisions of UL 96A to obtain a UL Master Label for system.

B. Install UL Master Label and attach to building at location directed by the Owner.

END OF SECTION

SECTION 26 43 13
SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.03 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.04 REFERENCES

A. ANSI/IEEE C62.33 – IEEE Guide on Testing of MOV components.

B. ANSI/IEEE C62.35 – IEEE Guide on Testing of SAD components.

C. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits.

D. ANSI/IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits.

E. ANSI/UL 1449 Third Edition (Version 3.0) - UL Standard for Safety for Surge Protective Devices.

F. CBEMA – Computer Business Equipment Manufacturers Association.

G. IEC 664 – International Engineering Consortium, Standard for Clamping Voltage.

H. National Electrical Code 285 - Surge Protection Devices.

I. NFPA 70 - National Electrical Code.

J. UL 67 – Listed for Internal Panelboard Transient Voltage Surge Suppressors.

K. UL 96A – Devices listed as approved for secondary surge arrestors (VZCA).

L. UL 248-1 - Fusing.

M. UL 1283 – Electromagnetic Interference Filters, Fifth Edition.

1.05 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
3. Installation instructions for each size and type of device.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Ten years from date of Substantial Completion, this includes workmanship, installation, and programming.

1.07 TESTING

A. Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of service entrance suppressor units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.
   1. Single pulse surge current capacity: Single pulse surge current tested in a mode at rated surge currents.
   2. Single pulse surge current capacity test: An initial UL 1449 defined 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit’s suppression voltage (VPR).
   3. A single 8 x 20µs waveform pulse of maximum rated surge current per mode shall then be applied. To complete the test, another UL 1449 surge shall be applied to verify the unit’s survival. Survival is achieved if the suppression voltage measured from the two UL1449 surges does not vary by more than 10 percent.

B. Minimum Repetitive Surge Current Capacity:
   1. Service entrance suppressor units should be tested repetitively at an independent lab to verify repetitive capacity.
   2. Minimum Repetitive Surge Current Capacity Test:
      a. An initial UL 1449 surge defined as 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit’s suppression voltage.
      b. A repetitive number of ANSI/IEEE C62.41.2-2002 (Category C3) surges, defined as a 1.2 x 50µs 10kV or 20kV open circuit voltage waveform and an 8 x 20µs 10,000A short circuit current waveform, shall then be applied at one-minute intervals.
      c. To complete the test, another UL 1449 surge shall be applied to verify the unit’s survival.
   3. Survival is achieved if the suppression voltage (VPR) does not vary by more than 10%.
   4. Proof of such testing shall be the test log generated by the surge generator.

C. Provide UL 1449 classification white sheet pages indicating the VPR for each SPD unit submitted for this product using the 6kV/3kA combination wave surge.

PART 2 - PRODUCTS

2.01 GENERAL SPD REQUIREMENTS

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

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.02 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Current Technologies, Current Guard Plus Series
   2. Liebert. ACV Series
   3. LEA International, CF Series

2.03 SERVICE ENTRANCE SUPPRESSORS

A. Service Entrance Suppressors – Non-Modular:
   1. For 480Y/277 volt, 3 phase, 4 wire, type 2, category C3 unit.
      a. Surge current capacity: 80,000/160,000 amps per protection mode/phase
      b. Nominal Discharge Current: 20 kA.
      c. Mounting: Refer to the Drawings.
      d. Voltage Protection Rating: Refer to requirements below.
      e. Components: Minimum component size of 20mm metal oxide varistors (MOV).

B. Secondary Distribution Suppressors – Non-Modular:
   1. For 480Y/277 and 208Y/120 volt, 3 phase, 4 wire, type 2, category B3/C1 unit.
      a. Surge current capacity: 60,000/120,000 amps per protection mode/phase
      b. Nominal Discharge Current: 20 kA.
      c. Mounting: Refer to the Drawings.
      d. Voltage Protection Rating: Refer to requirements below.
      e. Components: Minimum component size of modular 20mm metal oxide varistors (MOV).

C. Voltage Protection Rating:
   1. Protection modes and UL 1449 voltage protection rating for surge suppression units per each mode (L-N, L-L, L-G, and N-G as appropriate).
      a. 480Y/277 Volt, 3 phase, 4 wire.1200 Volt L-N, L-G, N-G and 1800 Volt L-L.
      b. 208Y/120 Volt, 3 phase, 4 wire. 700 Volt L-N, L-G, N-G and 1200 Volt L-L.

D. EMI/RFI Noise Rejection or Filtering:
   1. Each unit shall include a UL1283 first order, high-frequency filter for noise filtering between 10 KHz and 100 MHz.

E. Indication:
   1. Each unit shall include solid-state indicators with externally mounted LED visual status indicators that indicate on-line status of each protection mode of the unit.
   2. Each unit shall include an audible alarm with silencing switch to indicate when protection has failed.
   3. Provide each service entrance, secondary distribution, and critical load type unit(s) with a transient counter.
   4. Each unit shall contain form “C” contacts for remote indication of an alarm status.

F. Fuses:
   1. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit.
   2. Fuses shall be rated 200, 000 AIC minimum interrupting capacity.

G. Indoor Enclosures: NEMA 250, Type 1.

2.04 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Conductors and Cables."

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:
   1. Power Wiring: Comply with wiring methods in Section 26 05 19 “Conductors and Cables."

F. Additional Locations: Critical Load Protection – Fixed Equipment (120 Vac):
   1. Install an A3 hard-wired SPD between each of the following equipment items and its power supply conductors:
      a. Fire alarm master panel

3.02 FIELD QUALITY CONTROL

A. Perform the following inspections with the assistance of a factory-authorized service representative.
   1. Compare equipment nameplate data for compliance with Drawings and Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass inspections.

END OF SECTION

SECTION 26 51 00
LIGHTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Interior luminaires and accessories.
   2. Exterior luminaires, poles, and accessories.
   3. Emergency lighting units and exit signs.
   4. Luminaire supports.

B. Related Sections:
   1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, digitally addressable lighting control systems, and multi-pole lighting relays and contactors.
   2. Section 13 05 41 “Seismic Restraints” for restraints of equipment in the case of a seismic event.

1.02 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. LED: Light Emitting Diode

D. LER: Luminaire efficacy rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting fixture.

G. Pole: Luminaire support structure, including tower used for large area illumination.

1.03 SUBMITTALS

A. For each type of luminaire, arranged in order of luminaire designation. Include complete product model number and product data sheets on features, accessories, finishes, and the following:
   1. Physical description of luminaire including dimensions, as well as effective projected area for exterior luminaires.
   2. Details of attaching luminaires and accessories.
   3. Emergency lighting units including battery and charger.
   4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for fixture.
   5. LED photometric report per latest IESNA LM-79-08 testing guidelines, including luminaire model number, manufacturer of LED chip array/board and driver, input wattage, and independent testing laboratory name, report number, and date tested.
   6. Dimmer device data for all LED luminaires specified as dimming. Must be from approved manufacturer per luminaire manufacturer requirements, furnished and installed by contractor. Contractor responsible for dimmer control and luminaire compatibility.
   7. Pole information including: Materials, dimensions, finishes, means of attaching luminaire to support, anchor bolts and templates, structural analysis and manufactured pole foundations.

1.04 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, or by an independent agency complying with the IESNA Lighting Measurements Testing & Calculation Guides.

B. Comply with IEEE C2, “National Electrical Safety Code” and NFPA 70.

1.05 COORDINATION

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

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver luminaire and components to site. Store such that luminaires, finishes, lenses, and trims are protected. Install with protective films on and remove only after construction clean-up is complete.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation. Prevent breakage and damage to finish.

1.07 WARRANTY

A. Warranty Period for LED chips/arrays and drivers: 5 years from date of substantial completion.

B. Warranty Period for Emergency Lighting Unit Batteries, and self-powered exit signs: 5 years from date of substation completion.

C. Warranty Period for Luminaires: 5 years from date of substantial completion.

D. Warranty Period for Poles: 5 years from date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products: Refer to Luminaire Schedule on the drawings.

2.02 GENERAL REQUIREMENTS FOR LUMINAIRES AND COMPONENTS

A. All luminaires shall carry a UL listing, unless otherwise noted on the Luminaire Schedule. Exterior luminaires shall carry a UL wet location listing as well as designated IP rating, unless otherwise noted on the Luminaire Schedule.

B. Recessed Luminaires: Housing shall be constructed of steel or aluminum, free of burrs and sharp corners and edges, free of light leakage and accessible without use of tools. Components shall be formed and supported to prevent warping and sagging. Driver compartments shall be accessible from below the ceiling.
   1. Lensed troffers shall be provided with hinged door frames and positive spring-loaded latches, UV stabilized acrylic prismatic lenses with a minimum of 0.12 inch thickness, unless otherwise noted on the Luminaire Schedule.
   2. Direct/Indirect luminaire lamp chambers shall be made of one-piece perforated steel. Reflectors shall have a minimum reflectance of 90 percent.
   3. Volumetric luminaires shall have UV stabilized acrylic lens with optical pattern as designated on Luminaire Schedule. Reflectors shall have a minimum reflectance of 90 percent, painted after fabrication.
   4. Where fire-rated ceilings are specified, luminaires should be provided with listed enclosures meeting requirements to maintain fire-rated system rating.

C. Suspended Luminaires: Canopies, power feeds, and mounting accessories shall be coordinated with architectural-designated ceiling type. Luminaires shall be installed plumb and level at luminaire height designated on Luminaire Schedule.

D. Exterior Luminaires: Housings shall be rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Doors shall be removable for cleaning or replacing lenses, designed to disconnect driver when door opens.

1. Diffusers and Globes: Acrylic Lighting Diffusers shall be 100 percent virgin acrylic plastic, minimum 0.125 inch thickness. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation. Glass globes shall be annealed crystal glass unless otherwise indicated.
2. In-grade luminaires shall have separate compartments for wire entry and lamp chamber, separation shall prevent surface temperature of exceeding 115 degrees F.

E. LEED Requirement: Provide shielding to eliminate light trespass and shall be IESNA full cut-off classification to meet requirements.

2.03 LIGHT EMITTING DIODE (LED) LUMINAIRE SYSTEMS

A. Light emitting diodes shall have a minimum color rendering index (CRI) of 90 CRI for interior applications and 70 CRI for exterior applications. Refer to Luminaire Schedule for color temperature of the luminaires.

B. Color changing LED chip arrays shall have chip colors as noted on the Luminaire Schedule.

C. LED chips shall be wired so that operation of chip array is not prohibited by failure of one chip.

D. LED Driver:
1. Solid state driver with integral heat sink. Driver shall have overheat, short-circuit and overload protection, power factor 0.90 or above and maximum total harmonic distortion of 20 percent. Surge suppression device for all exterior luminaires.
2. Drivers shall have dimming capabilities as outlined in the luminaire schedule for each luminaire type.
3. Driver shall have a minimum of 50,000 hours rated life.

2.04 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
1. Fixture for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
a. Battery: Sealed, maintenance-free, nickel-cadmium type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.05 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
1. Battery: Sealed, maintenance-free, lead-acid type.

2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or luminaires.
7. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.06 EMERGENCY INVERTER – LED LUMINAIRES

A. Individual Unit: Self-contained, with automatic transfer to battery supply on loss of normal power, UL 924 listed for factory of field installation in indoor and damp locations.

B. Battery: Sealed, high temperature, maintenance free, nickel cadmium battery with capacity to provide 90 minutes of emergency operation at full lumen output, with 24-hour recharge time, seven (7) year minimum battery life expectancy.

C. Features: Integral battery charger with LED charging indicator light, test switch, electronic circuitry for use with LED drivers. Output of inverter shall be sinusoidal with solid-state low voltage disconnect circuit.

D. Inverter to be mounted remote and adjacent to luminaire shown on drawings. Inverter to be accessible from below ceiling through luminaire opening.

E. Charging indicator LED and test switch to be mounted in remote test/monitor plate provided with inverter or integral to luminaire.

F. Inverter capable of operating a switched, dimmed, or unswitched luminaire up to 30 watts at full lumen output.

G. Warranty: Emergency inverter shall have a full five (5) year, non-prorated warranty.

2.07 LUMINAIRE SUPPORT COMPONENTS

A. Comply with Section 26 0529 "Hangers and Supports" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Comply with Section 13 05 41 “Seismic Restraints”.

C. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

D. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single luminaire. Finish same as luminaire.

E. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gauge.

F. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.

G. Hook Hangers: Integrated assembly matched to luminaire and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.08 ACCEPTABLE MANUFACTURERS – POLES

A. Manufacturer of Luminaire.

B. Valmont Poles.

C. Shakespeare Composite Structures.

D. United Lighting Standards Inc.

E. Gardco Poles.

F. Ameron Poles.

2.09 LIGHTING POLES

A. Poles: Aluminum, square and straight lighting pole with embedded anchor base.

B. Structural Characteristics: Comply with AASHTO LTS-4-M.
   1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed 100mph with a gust factor of 1.3 with luminaires, brackets, and banners mounted.

C. Handhole: 2 inches x 4 inches with weatherproof cover secured by stainless-steel captive screws. Provide gasket with matching finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

E. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

F. Anchor Bolts: As recommended by pole manufacturer, installed per manufacturer's template with washers and hex nuts. Grout between anchor plate and concrete base with non-shrink grout after pole is plumbed.

G. Vibration Damper: As recommended by pole manufacturer, internal to pole. Provide additional pole top damper for first mode vibration on single-head poles where recommended by manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Luminaires:
   1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
   2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Lay-in Ceiling Luminaire Supports: Use grid as a support element.
   1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inches (150 mm) from luminaire corners.
   2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
   3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
   4. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the weight of luminaire at a safety factor of 3.

D. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
   2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
   4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

E. When installing luminaires, the contractor shall use the luminaire manufacturer's mounting hardware and follow all manufacturer's installation direction.

F. All recessed downlights must be installed so that the bottom of the throat is even with the finished ceiling plane. The overlapping flange must then fit flush to the ceiling plane/throat. No light leak must be visible. All miscellaneous hardware above the ceiling plane to accomplish the above shall be included in the base bid.

G. All recessed downlights shall have self-flanged reflectors unless otherwise noted.

H. When luminaires are installed in continuous rows of 2 or more, luminaires shall be approved for use as wireway.

I. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

J. Raise and set poles using web fabric slings (not chain or cable), or non-chafing ropes.

K. Ground-Mount Luminaires: Align units for optimum directional alignment of light distribution. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, shape base to match shape of bollard base. Finish by troweling and rubbing smooth.

L. Ground metal and non-metallic poles and support structures according to Section 26 05 26 "Grounding and Bonding."

3.02 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.03 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.

C. Illumination Observations: Verify normal operation of luminaires after installing luminaires and energizing circuits with normal power source.

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.04 ADJUSTING AND CLEANING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.

B. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires. Touch up luminaire and pole finishes as necessary.

C. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

END OF SECTION

SECTION 27 01 00
TELECOMMUNICATIONS CABLING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. All telecommunication systems shall be provided per National Guard Telecommunication Specifications.

B. Related Sections include the following:
   1. Division 13 Section "Seismic Restraints" for products and installation requirements necessary for compliance with seismic criteria.

1.2 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
   1. ASTM International (ASTM):
      a. ASTM D 709 (2017) Laminated Thermosetting Materials.
   2. Electronic Components Industry Association (ECIA):
      a. ECIA EIA/ECA 310 (2005) Cabinets, Racks, Panels and Associated Equipment.
   3. Telecommunications Industry Association (TIA):
      a. TIA-1152 (2009) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.
      b. TIA-455-21 (1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices.
      c. TIA-526-14 (2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
      d. TIA-526-7 (2015a; R 2008) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
      e. TIA-568-C.0 (2009; Add 1 2010; Add 2 2012) Generic Telecommunications Cabling for Customer Premises.
      f. TIA-568-C.1 (2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard.
      g. TIA-568-C.2 (2009; Errata 2010; Add 2 2014; Add1 2016) Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
      h. TIA-568-C.3 (2008; Add 1 2011) Optical Fiber Cabling Components Standard.
      i. TIA-569 (2015d) Commercial Building Standard for Telecommunications Pathways and Spaces.
      j. TIA-570 (2012c) Residential Telecommunications Infrastructure Standard.
      k. TIA-606 (2017c) Administration Standard for the Telecommunications Infrastructure.
      l. TIA-607 (2011b) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
      m. TIA/EIA-598 (2014D; Add 2 2018) Optical Fiber Cable Color Coding.
      n. TIA/EIA-604-10 (2002a) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC.
      o. TIA/EIA-604-12 (2000) FOCIS 12 Fiber Optic Connector Intermateability Standard Type MT-RJ.
      p. TIA/EIA-604-2 (2004b; R 2014) FOCIS 2 Fiber Optic Connector Intermateability Standard.
      q. TIA/EIA-604-3 (2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3.
      r. TIA-758-B Customer-Owned Outside Plant Telecommunications Infrastructure.
      s. TSB-162-A TIA Systems Bulletin Telecommunications Cabling Guidelines for Wireless Access Points.

4. Institute of Electrical and Electronics Engineers (IEEE):
   a. IEEE Std 100 (2000) The Authoritative Dictionary of IEEE Standards Terms.
5. Insulated Cable Engineers Association (ICEA):
   a. ICEA S-83-596 (2016) Indoor Optical Fiber Cables.
   b. ICEA S-90-661(2012) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cable for Use in General Purpose and LAN Communications Wiring Systems.
6. National Electrical Contractors Association (NECA):
   a. NECA/BICSI 568 (2006) Standard for Installing Building Telecommunications Cabling.
7. National Electrical Manufacturers Association (NEMA):
   a. NEMA WC 66 (2013) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs.
8. National Fire Protection Association (NFPA):
   a. NFPA 70 (2017 with Errata 1-2, TIA 17-1 through TIA 17-17) National Electrical Code.
   b. NFPA 780 (2017) Standard for the Installation of Lightning Protection Systems.
9. U.S. Federal Communications Commission (FCC):
   a. FCC Part 68 Connection of Terminal Equipment to the Telephone Network (47 CFR 68).
10. Underwriters Laboratories (UL):
   a. UL 1286 (2008, Reprint Jan 2018); UL Standard for Safety Office Furnishings.
   b. UL 1666 (2007, Reprint June 2012) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
   c. UL 1863 (2004, Reprint Sep 2016) UL Standard for Safety Communication Circuit Accessories.
   d. UL 444 (2008 ; Reprint Apr. 2015) Communications Cables.
   e. UL 467 (2013; Reprint June 2017) UL Standard for Safety Grounding and Bonding Equipment.
   f. UL 50 (2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.
   g. UL 514C (2014, Reprint Dec 2014) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
   h. UL 723 (2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Material.
   i. UL 969 (2017, Reprint May 2018) UL Standard for Safety Marking and Labeling Systems.
11. U.S. Federal Military Standard:
   a. MIL-STD-188-124B (2000) Grounding, Bonding and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications – Electronics Facilities and Equipments.
   b. MIL-HDBK-419A (1987) Grounding, Bonding and Shielding for Electronic Equipments and Facilities.
   c. Technical Criteria for the Installation Information Infrastructure Architecture – I3A – 2008.
12. Unified Facilities Code (UFC):
   a. UFC 1-300-01 Criteria Format Standard.
   b. UFGS-16710 09 (2004) Structured Telecommunications Cabling and Pathway System.
   c. UFC 1-200-01 General Building Requirements.
   d. UFC 3-580-01 (June 2016 with Change 1) Telecommunications Interior Infrastructure Planning and Design.

13. Other:
    a. EN 50173 (1996) Information Technology – Generic Cabling Systems.
    b. EN 50174-1 (2001) Information Technology – Cabling Installation, Part 1: Specification and Quality Assurance.
    c. EN 50174-2 (2001) Information Technology – Cabling Installation, Part 2: Installation Planning and Practices Inside Buildings.
    d. EN 50174-3 (2002) DRAFT Information Technology – Cabling Installations, Part 3: Installation Planning and Practices Outside Buildings
    e. ISO/IEC 11801 (2002) Information Technology – Generic Cabling for Customer Premises
    f. ISO/IEC 14763-1 (1999) Information Technology – Implementation and Operation of Customer Premises Cabling, Part 1: Administration
    g. ISO/IEC 14763-2 (2000) Information Technology – Implementation and Operation of Customer Premises Cabling, Part 2: Planning and Installation
    h. ISO/IEC 14763-3 (2000) Information Technology – Implementation and Operation of Customer Premises Cabling, Part 3: Testing of Optical Fiber Cabling
    i. MIL-HDBK-419A Grounding, Bonding, and Shielding for Electronic Equipment and Facilities

1.3 DEFINITIONS

A. Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.0-D, TIA-568.1-D, TIA-568.2-D, TIA-568.3-D AND TIA-568.4-D – (with addendums and erratas), TIA-569, TIA-606 and IEEE Std 100 and herein.

B. Campus Distributor (CD). A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

C. Building Distributor (BD). A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

D. Floor Distributor (FD). A distributor used to connect horizontal cable and cabling subsystems or equipment. (International express for horizontal cross-connect (HC).)

E. Telecommunications Room (TR). An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

F. Entrance Facility (EF) (Telecommunications). An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

G. Equipment Room (ER) (Telecommunications). An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

H. Open Cable. Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

I. Open Office. A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

J. Pathway. A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

A. The building telecommunications cabling, and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intra-building and inter-building interconnecting cabling, pathway, and terminal hardware. The intra-building backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star.

B. Provide telecommunications pathway system referenced herein as specified in Section 26 05 33 “Raceways.”

1.5 SUBMITTALS

A. General: Refer to “Submittal Register” for all required submissions of this specification section. All required submissions of this specification section are to be submitted for review in one all-inclusive submission. Partial or incomplete submissions will be rejected. A single all-inclusive submission per this specification section is required to allow a complete and concise review of the requested submittal content.

B. Shop Drawings:
   1. Submit plan drawings (minimum of 11x17 using a minimum scale of 1/8 inch per foot.)
   2. Include wiring diagrams and installation details of the equipment indicating proposed locations, layout and arrangement, control panels, accessories, piping, ductwork and other items that must be shown to ensure a coordinated installation.
   3. Submit wiring diagrams that clearly identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.
   4. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

C. Telecommunications Drawings:
   1. Provide registered communications distribution designer (RCDD)-approved drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and to the telecommunications work area outlets. The following drawings shall be provided as a minimum:
      a. T1: Layout of complete building per floor – Building Area/serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system and other systems needed to be viewed from the complete building perspective.
      b. T2: Serving Zones/Building Area Drawings – Drop Locations and Cable Identification (ID’s). Shows a building area or serving zone. These drawings show drop locations, telecommunication rooms, access points and detail call outs for common equipment rooms and other congested areas.
      c. T4: Typical Detail Drawings - Faceplate and Patch Panel Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT).

Detailed drawings of symbols and typical items such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways. All details shall meet each IMD and Network Enterprise Center specifications.

D. Telecommunications Space Drawings
   1. Provide T3 drawings in accordance with TIA-606 that includes telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical and electrical layout, and cabinet, rack, backboard and wall elevations.
   2. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinets or racks.
   3. Drawing shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

E. Telecommunications Qualifications:
   1. Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

F. Telecommunications Contractor:
   1. The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

G. Key Personnel:
   1. Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.
   2. Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.
   3. In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years' experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling

systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

4. Indicate that all key persons are currently employed by the telecommunications contractor or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.
5. Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor’s key personnel require approval from JJK-SP, LLC.

H. Minimum Manufacturer Qualifications:
1. Cabling, equipment and hardware manufacturers shall have a minimum of 3 years’ experience in the manufacturing, assembly, and factory testing of components that comply with TIA-568.D.1, TIA-568.D.2 and TIA-568.D.3.

I. Test Plan:
1. Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the UTP and optical fiber components and accessories 60 days prior to the proposed test date. Include procedures for certification, validation, and testing. IMD and NEC to approve test plan prior to start of testing.

J. Regulatory Requirements:
1. In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

K. Standard Products:
1. Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

L. Alternative Qualifications:
1. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

M. Material and Equipment Manufacturing Date:
1. Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.6 DELIVERY AND STORAGE

A. Provide protection from weather, moisture, extreme heat and cold, dirt, dust and other contaminants for telecommunications cabling and equipment placed in storage.

1.7 WARRANTY

A. The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 MAINTENANCE

A. Operation and Maintenance Manuals:
   1. Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system.

B. Record Documentation:
   1. Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cutovers and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Provide the following T5 drawing documentation as a minimum:
      a. Cables: A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include only the required data fields in accordance with TIA-606. Include manufacture date of cable with submittal.
      b. Termination Hardware: A record of contractor installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.
   2. Record Documentation shall be in compliance with National Guard and UFC requirements.
   3. Provide laminated as-built drawings in each telecommunication room with outlet numbers and final room numbers. The laminated drawing shall be Architectural D size.

PART 2 - PRODUCTS

Products furnished within the limits of this specification are subject to the requirements of the Buy American Act under provisions of the prime contract.

2.1 COMPONENTS

A. UL or Third Party Certified: Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

B. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets or racks. Cabling and interconnecting hardware and

components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

A. Provide telecommunications pathways in accordance with TIA-569 and as indicated on the drawings and specification section 26 05 33 “Raceways.” Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

A. Cabling shall be UL listed for the application and shall comply with TIA-568.D.1, TIA-568.D.2 and TIA-568.D.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels bearing manufacture date for UTP in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

B. Backbone Cabling:
   1. Backbone Copper:
      a. Copper backbone cable shall be solid conductor, 24 AWG, 100 ohm, 200-pair, Category 3, UTP, in accordance with ICEA S-90-661, TIA-568-D.1, TIA-568-D.2 and UL 444, formed into 25 pair binder groups with a gray thermoplastic jacket. Cable shall be imprinted with manufacturer’s name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular length marking intervals in accordance with ICEA S-90-661. Provide general purpose (CM or CMB) communication rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.
   2. Backbone Optical Fiber:
      a. Provide in accordance with ICEA S-83-596, TIA -568-C.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.
      b. Provide the number of strands indicated, but not less than 12 strands between the main telecommunication room and each other telecommunication room of single-mode (OS1), tight buffered fiber optic cable.
      c. Provide general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit and group color shall be in accordance with TIA/EIA-598.

C. Horizontal Cabling:
   1. Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568.D.1.

D. Horizontal Copper:
   1. Provide horizontal copper cable in accordance with TIA-568.D.2, UL 444, NEMA WC 66, ICEA S-90-661 UTP (unshielded twisted pair), 100 ohm. Provide four each individually twisted pair, 24 AWG conductors, Category 6, with a thermoplastic jacket and color as specified on drawings. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular intervals in accordance with ICEA S-90-661. Provide communications general purpose (CM or CMG), communications plenum (CMP) or communications riser (CMR) rated cabling in accordance with NFPA 70. Substitution of a higher rated cable hall be permitted in accordance with NFPA 70.
   2. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.4 TELECOMMUNICATIONS SPACES

A. Provide connecting hardware and termination equipment in the telecommunications entrance facility (and telecommunication equipment rooms) to facilitate installation as shown on the design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

B. Backboards:
   1. Provide void-free, interior grade A-C plywood 3/4 inch thick (4 feet by 8 feet) as indicated. Backboards shall be fire rated by the manufacturing process. The fire stand shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication space. Fire stamp shall face out on the backboard (do not cover).

C. Equipment Support Frame:
   1. Provide in accordance with ECIA EIA/ECA 310-D and UL 50:
      a. Racks, 84 inches high by 19 inches wide, floor mounted modular type, 16 gauge steel or 11 gauge aluminum construction, minimum, treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, a surge protected power strip with six duplex 20 amp, 115 volt receptacles. Surge strips shall not have integral disconnect switch. Rack shall be compatible with 19 inch panel mounting.
      b. Provide 25 percent spare capacity within each utilized rack. Provide one spare rack for every four utilized racks, with a minimum of one spare rack per telecommunication space.
      c. Horizontal cable management shall be provided for the 19 inch rack with a channel approximately 2 inches by 2 inches.
      d. Rear wire frame shall be provided for double sided management, Hubbell HC219 series.
      e. Hinged rear covers shall be provided for LAN racks (JSN #A0903).

D. Cable Guides:
   1. Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inch equipment racks and telecommunications backboards. Cable guides of ring or bracket type devices for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws and or nuts and lockwashers.

E. Patch Panels:
   1. Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified.
   2. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568.D.1, TIA-568.D.2 and TIA-568.D.3. Patch cords shall meet minimum performance requirements specified in TIA-568.D.1, TIA-568.D.2 AND TIA-568.D.3 for cables, cable length and hardware specified.
   3. Provide sufficient patch cables with orange jacket, of various appropriate lengths, to terminate all horizontal and backbone copper and fiber optic cable, plus 25 percent spare.

2.5 TELECOMMUNICATIONS OUTLET AND CONNECTOR ASSEMBLIES

A. Outlets and Connectors for Copper:
   1. Outlets and connectors shall comply with FCC Part 68TIA-568.D.1 and TIA-568.D.2. UTP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568.D.2 Category 6 requirements. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlets and connectors shall be

terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each connector shall be wired T568B as indicated. UTP connectors shall comply with TIA-568.D.2 for 200 mating cycles.

B. Optical Fiber Connections
   1. Provide in accordance with TIA-455-21.
   2. Fiber optic adapters and connectors shall be TIA/EIA “LC” type. ST style adaptors shall not be used.

C. Cover Plates:
   1. Telecommunications cover plates shall comply with UL 514C, and TIA-568.D.1, flush design constructed of stainless steel or high impact thermoplastic material to match color of receptacle and switch cover plates. Provide labeling in accordance with the paragraph LABELING in this section.
   2. Cover plates and labeling shall meet UFC and National Guard specifications.

2.6 GROUNDING AND BONDING PRODUCTS

A. Provide in accordance with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Provide bonding conductors and grounding bus bars.

B. Building Entrance Protectors (BEP)
   1. Wall mounted gas tube BEP with 5-pin protector modules.
   2. BEP shall have 110 connector input, output and cover.
   3. Circa model 1880ECA1-200G for 200-pair cable or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568.D1, TIA-568.D.2 AND TIA-568.D.3, TIA-569, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

B. Conduit system, cable tray and communication system components shall be supported in compliances with Specification Section 13 05 41 “Seismic Restraints.”

C. Cabling:
   1. Install Category 6 UTP telecommunications cabling system as detailed in TIA-568.C.1, TIA-568.D.2 and TIA-568.D.3. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not untwist Category 6 UTP cables more than 1/2 inch one half inch from the point of termination to maintain cable geometry. Provide service loop on each end of the cable, 10 feet 10 ft. in the telecommunications room, and 12 inches in the work area outlet. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with National Guard and UFC specifications.

D. Open Cable:

1. Use only where specifically indicated on plans for use in cable trays. Install in accordance with TIA-568.D.1 and TIA-568.D.2. Do not exceed cable pull tensions recommended by the manufacturer. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 12 inches shall be maintained when such placement cannot be avoided.

E. Horizontal Cabling:
1. Install horizontal cabling as indicated on drawings between the campus distributor, floor distributors, and the telecommunications outlet assemblies at workstations.

F. Pathway Installations:
1. Provide in accordance with TIA-569 and NFPA 70.

G. Work Area Outlets:
1. Cover Plates:
a. Cover plates and labeling shall meet National Guard and UFC specifications.
2. Cables:
a. Unshielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.
b. Cable labeling shall meet UFC and National Guard specifications.
3. Pull Cords:
a. Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.
4. Telecommunications Space Termination.
5. Install termination hardware required for Category 6. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

H. Connector Blocks:
1. Connector blocks shall be rack mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

I. Patch Panels:
1. Patch panels shall be mounted in equipment cabinets racks with sufficient ports to accommodate the installed cable plant plus 25 percent spares.
a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel as recommended by the manufacturer to prevent movement of the cable.
b. Fiber Optic Patch Panel. Fiber optic cable loop shall be provided as recommended by the manufacturer. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

J. Equipment Support Frames:
1. Equipment Support Frames shall meet National Guard and UFC Specifications.
2. Install in accordance with TIA-569:
a. Bracket, wall mounted. Mount bracket to plywood backboard in accordance with manufacturer's recommendations. Mount rack so height of highest panel does not exceed 78 inches above floor.
b. Racks, floor mounted modular type. Permanently anchor rack to the floor in accordance with manufacturer's recommendations.
c. Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets.

d. Cabinets, wall-mounted modular type. Mount cabinet to plywood backboard in accordance with manufacturer's recommendations. Mount cabinet so height of highest panel does not exceed 78 inches above floor.

3.2 LABELING

A. Labels:
1. Labeling shall meet National Guard and UFC Specifications.
2. Provide labeling in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using laser printer.
3. Building Entrance Protector Terminals (BEP) and Protected Entrance Terminals (PET) shall be labeled with yellow 1” x 1” sized labels or 1” high rolled reflective label. The labels shall have a top line identifying the Building Number, a Second Line identifying the CA ID number and a third number identifying the CA count.
4. Copper cables shall be identified with the size and type and cable id and count.
5. Fiber Optic Patch Panels (FOPP) labeling shall consist of the fiber optic identification, the number and type of strands and the CA count. All underground cable, including maintenance loops shall be labeled where it enters and exits a maintenance vault or Telecommunication Room and on each side of the service loop. Labeling shall be done in accordance with specifications.
6. Equipment racks shall be labeled with consecutive letters; starting with “A” for the first Data rack and continuing to the voice racks labeled with the next available letter.
7. All patch panels shall be labeled consecutively including voice tie patch panels.
8. Label system for devices shall be: “Comm Room, Rack, Patch Panel, Port Number.”

B. Cable:
1. Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

C. Termination Hardware:
1. Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 TESTING

A. Telecommunications Cabling Testing:
1. Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568.D.1, TIA-568.D.2 and TIA-568.D.3. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.
2. Testing shall be in compliance with National Guard and UFC testing requirements.

B. Inspection:
1. Visually inspect UTP for UL or third-party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments and inspect cabling connections to confirm compliance with TIA-568. C.1, TIA-568. C.2 and TIA-568.C.3. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

C. Verification Tests:
1. UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connected.

D. Performance Tests:
1. Perform testing for each outlet as follows:

a. Perform Category 6 link tests in accordance with TIA-568.D.1, TIA-568.D.2 and TIA-568.C.3. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.
b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568.D.1 and TIA-568.D.3.

E. Final Verification Tests:
1. Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.
a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.
b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

F. Test Submission:
1. Submit all test results for voice and data cable installation within one week of completion of testing.
2. Test results and certifications shall be submitted in electronic format only.

END OF SECTION

SECTION 28 31 11
DIGITAL, ADDRESSABLE FIRE-ALARM AND MASS NOTIFICATION SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Fire Alarm and Detection Systems.
   2. Mass Notification Systems.

B. Related Sections include the following:
   1. Division 13 Section "Seismic Restraints" for products and installation requirements necessary for compliance with seismic criteria.

1.03 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.04 PERFORMANCE REQUIREMENTS

A. The fire alarm and mass notification design documents and this specification section describe the minimum required features, material quality and operational requirements of the fire alarm system. These documents do not depict every connection to be made and wire to be installed. The Vendor and Contractor are solely responsible for determining all wiring, programming, interconnections and additional equipment required to create a complete and fully functional fire alarm and mass notification system, based on the equipment and performance characteristics described within these documents.

B. Device layouts and limited equipment have been shown on the construction documents. Additional equipment, wiring, components, etc required to create a complete and fully functional system has not been shown and is the responsibility of the Contractor. Shop drawing submittals shall indicate all requirements to create said fire alarm system.

1.05 SUBMITTALS

A. General Submittal Requirements:
   1. Failure to comply with all of the requirements within specification 26 05 00 and within this specification section will result in the submitted shop drawing being rejected without review. All listed requirements must be submitted within a single submittal package.
   2. Shop Drawings shall be prepared by persons with the following qualifications:
      a. Trained and certified by manufacturer in fire-alarm system design.
      b. NICET-certified fire-alarm technician, Level III minimum.
      c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product indicated on drawings and required to complete installation if not indicated on drawings. Indicate part numbers being ordered for each equipment or component variation required. If device or equipment is shown on construction documents, indicate corresponding fire alarm symbol at the top of each product data sheet.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Include CAD floor plans indicating the complete layout of the entire system, including auxiliary equipment, wiring and device addresses.
      a. A legend shall be provided to indicate which fire alarm symbols correspond with construction document fire alarm symbols, if different.

2. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
3. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
4. Provide equipment rack elevation, console layout, grounding detail and amplifier power calculations for voice alarm systems.
5. Manufacturer wiring requirements, such as size, type and manufacturer.
6. Photocopy of NICET certification of person overseeing the preparation of fire alarm drawings, shop drawings, installation and testing.
7. Stamp and signature of Professional Engineer overseeing fire alarm design shall be required on drawings as required to comply with local or state regulations.

D. Installation and maintenance manuals per Section 26 05 00.

E. Field quality-control reports.

F. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
   a. Frequency of testing of installed components.
   b. Frequency of inspection of installed components.
   c. Requirements and recommendations related to results of maintenance.
   d. Manufacturer's user training manuals.
4. Provide shop drawings as reviewed by the Architect/Engineer and Authority Having Jurisdiction.
5. Provide hardcopy and electronically reproducible CAD floor plans indicating location of fire alarm devices, wiring and associated addresses.

G. Software and Firmware Operational Documentation:
1. Device address list.

H. Project Record Documents:
1. Submit record documents per Section 26 05 00.
2. Provide a CAD drawing of each building area depicting each device location and address. Labeling of devices on drawings shall be consistent with labeling in the field. Scale CAD drawings no smaller than 1/16 inch = 1 foot-0 inch.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: A factory authorized, licensed electrical or security contractor with minimum 5 years experience in the design, installation and maintenance of fire alarm and mass notification systems by fire alarm system manufacturer specified and selected. Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. Source Limitations for Fire-Alarm and Mass Notification System and Components: Obtain system from single source from single manufacturer.

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

E. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.07 SYSTEM DESCRIPTION

A. UL-certified automatic and manual addressable fire alarm system with mass notification, consisting of multiplexed signal transmission, dedicated to fire-alarm and mass notification service only. Compliant with NFPA 72.

B. Alarm Indication: By synchronized sounding of emergency voice alarm communication system and tone signals, synchronized flashing of strobes, and illumination of LED text sign. Tone and visual signals shall be synchronized throughout the facility.

C. Voice Communication: An emergency voice alarm communication system shall be utilized to notify occupants of fire alarm initiation and provide instructions to evacuate the facility using digitized voice messages. Manual voice override functionality shall be provided.

1.08 WARRANTY

A. Provide one year warranty for all labor and materials from date of Substantial Completion.

1.09 ANNUAL SERVICE CONTRACT

A. As a separate line item within the bid, provide cost to inspect, service, and test all fire alarm system devices and equipment per NFPA requirements for one (1) year following the warranty period. Written reports of inspection and testing shall be submitted per NFPA 72, Chapter 14 requirements.

B. The Owner has the right to seek a contract with the Fire Alarm vendor outside of the parameters of this specification. In that case, the requirements of this specification are not intended to be binding.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products from a single source. Approved manufacturers include the following:
   1. Notifier.
   2. Siemens Building Technologies Inc.; Fire Safety Division.
   3. Simplex.
   4. Edwards.
   5. Honeywell.

2.02 FIRE ALARM CONTROL PANEL

A. General: Comply with UL 864, “Control Units for Fire-Protective Signaling Systems.”

B. Cabinet: Lockable steel enclosure with transparent opening for viewing all indicators. Arrange panel so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control panel, provide exactly matching modular unit enclosures. Accommodate all components to allow ample gutter space for interconnection of panels as well as field wiring. Identify each enclosure by an engraved, red-laminated, phenolic resin nameplate. Lettering on the enclosure nameplate shall not be less than 1 inch high. Identify individual components and modules within the cabinets with permanent labels. Provide provisions for electrical conduit connections within the top and sides of the cabinet.

C. Parameters:

1. Minimum Total Addressable Points: 500.
2. Minimum Total SLC Loops: 4.

D. Central Processing Unit:
1. The Central Processing Unit shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the Central Processing Unit.
2. The Central Processing Unit shall contain and execute all control-by-event programs for specific action to be taken if an alarm condition is detected by the system. These programs shall be stored in non-volatile programmable memory.
3. The Central Processing Unit shall provide a real-time clock for time annotation of all system events.
4. All power for the central processing unit shall be provided and supervised by the Fire Alarm Control Panel.

E. Signal Line Circuit Board (SLC):
1. Each circuit board shall contain its own microprocessor and shall be capable of operating in local/degrade mode.
2. Each circuit board shall provide power and communicate with all intelligent addressable detectors and modules on a single pair of wires.
3. The system shall be designed such that each signaling line circuit is limited to only 80 percent of its total capacity at initial installation.
4. Pathway Class Designation: Class B: Circuits not capable of transmitting an alarm beyond the location of the fault condition. Does not include a redundant path.

F. Notification Appliance Circuit Board (NAC):
1. Each board shall contain its own microprocessor and shall be provided to control each notification appliance circuit. The board shall communicate and provide power to all devices on its loop.
2. Pathway Class Designation: Class B: Circuits not capable of transmitting an alarm beyond the location of the fault condition. Does not include a redundant path.

G. Display:
1. The system display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.
2. The display assembly shall contain and display custom alphanumeric labels for all intelligent detectors, addressable modules and software zones.
3. The system display shall provide a backlit alphanumeric liquid crystal display (LCD) and status indicators for the following system parameters: AC Power, System Alarm, System Trouble, Display Trouble, CPU Failure and Signal Silence.
4. An alphanumeric touch keypad shall be provided for control capability to command all system functions and for field programming. Two different password levels shall be provided for Administrator and User credentials to prevent unauthorized system control or programming.
5. Displayed descriptions of addressable points shall include actual room names and numbers as selected by Owner. Coordinate descriptions with Owner prior to programming.

H. Power Supply:
1. The addressable main power supply shall operate at 120VAC, 60Hz and shall provide all necessary power for the Fire Alarm Control Panel. Components requiring 120VAC power shall be provided by a dedicated emergency branch circuit using two #12 conductors and one #12 ground in 1/2 inch conduit from a dedicated 20A, single pole circuit breaker with a red handle and manufacturer handle lock-on device.

a. Initiating devices, notification appliances, signaling lines and trouble signals shall be provided by a 24VDC power source, obtained from the 120VAC service and power supply module.
b. The 24VDC power supply system shall consist of batteries, automatic battery charger and automatic transfer upon primary power failure. Provide additional batteries as required.

2. All power supplies shall conform to NFPA and UL864 for power-limiting requirements.
3. Integral battery chargers shall be provided with the main power supply for use with internal batteries. Battery capacity shall be sufficient for operation of the entire system for 24 hours in a non-alarm state, followed by alarm mode for 15 minutes, plus 25 percent spare capacity for future devices.
4. The power supply, primary power, battery presence, and battery voltage shall be electrically supervised.

I. Universal Digital Alarm Communicator Transmitter (UDACT):
1. Provide UDACT mounted within fire alarm control cabinet in a standard module position. As an option, the UDACT may have the ability for remote mounting. The wire connections between the UDACT and the fire alarm control panel shall be supervised.
2. Provide dual phone line interface capable of fire alarm notification to the local fire alarm department, fire protection agency or monitoring service. Communicator shall be capable of transmitting events in a format compatible with receiving station.
3. Communicator shall be FCC registered. Contractor shall provide two RJ31X jacks and provide connection of communicators to Owner’s telephone system.

J. Monitoring and Certification:
1. The fire alarm equipment supplier shall provide Central Station Monitoring Service in full compliance with the applicable version of NFPA 72. This shall include runner services for alarm, trouble and supervisory conditions, maintenance and service agreements as well as UL listed monitoring service.
2. The fire alarm equipment supplier shall provide either a UL Certificate or Factory Mutual (FM) Placard on the installed system. This shall include full compliance with NFPA 72 initial inspection and testing chapters including all required documentation. The documentation shall include, but not be limited to, voltage drop and battery calculations, device wiring, as-built drawings, record of completion, and copy of fire alarm panel programming and central station history report. The equipment supplier must provide a UL Certificate or FM Placard as well as UL Category UUFX monitoring service in order to meet these requirements.
3. The UL Certificate or FM Placard must be installed at the fire alarm control panel. If this certificate or placard is not installed at the time of substantial completion, written confirmation proving the certificate or placard has been issued by the appropriate agency must be provided.

K. Surge Protection:
1. The fire alarm control panel shall be furnished with an integral surge protection device. Refer to Section 26 43 13 for requirements.

L. History Storage:
1. The fire alarm control panel shall utilize battery-protected non-volatile memory to store a minimum of 400 events in a log.
a. These events shall be stored in memory until downloaded or manually cleared. Resetting of the control panel shall not clear the memory.

M. Digital Voice Command Center:

1. The Digital Voice Command Center, located with the Fire Alarm Control Panel, shall contain all equipment required for audio control, signaling and supervisory functions. It shall include speaker zone indication and control, digital voice units, and microphone.
2. Function: The Digital Voice Command Center equipment shall perform the following functions:
   a. Provide automatic annunciation of digitally recorded voice messages and tones.
   b. Operate as a supervised, single-channel emergency voice communication system.
   c. Audibly and visually annunciate the active or trouble condition of every speaker circuit and firefighter phone circuit.
   d. Audibly and visually annunciate any trouble condition for digital tone and voice units required for normal operation of the system.
   e. Provide all-call emergency paging activities through activation of a single control switch.
3. Audio Amplifiers:
   a. The audio amplifiers shall provide single channel audio power at 25 Volts RMS for distribution to speaker circuits.
   b. Provide multiple audio amplifiers to supply incremental audio power or to function as an automatically switched backup amplifier system.
   c. The audio amplifier shall include an integral power supply, and shall provide built-in LED indicators for the following conditions:
      1) General Trouble.
      2) Fault.
      3) Power Supply Abnormal Condition.
      4) Battery Trouble.
      5) Audio Transmit/Receive.
   d. Adjustment of the correct audio level for the amplifier shall not require any special tools or test equipment.
   e. Amplifiers shall include audio input and amplifier output supervision and backup input with automatic switch over function if primary amplifier should fail.
4. Audio Message Generator (Digitized or Prerecorded Voice):
   a. Each initiating zone or intelligent device shall interface with an emergency voice communication system capable of transmitting a prerecorded voice message to all speakers in the building.
   b. Actuation of any alarm initiating device shall cause a prerecorded message to sound over the speakers. The message shall be repeated four (4) times. Pre-and-post-message tones shall be supported.
      1) Coordinate all prerecorded messages with Owner and Authority Having Jurisdiction. Prerecorded messages shall be from a male voice and shall be in English and/or the multi-lingual language of the majority of the building occupants.
   c. Messages shall be annunciated by a single channel in all evacuation signal zones throughout the building.
   d. A built-in microphone shall be provided to allow paging through speaker circuits.
   e. The audio message generator shall have the following indicators to allow for proper operator understanding:
      1) General Trouble.
      2) Microphone Trouble.
      3) Busy/Wait.
      4) All-Call.
      5) In-Use.

N. Fire Alarm Panel Functions:

1. The trouble indicator light shall illuminate if the fire alarm control panel reports the following from any panel or annunciator on the system:
   a. Low battery or battery voltage.
   b. Abnormal switch or control position.
   c. Battery or charger failure.
   d. Ground fault, open circuit or short circuit.
   e. AC power loss or irregularity.
   f. Module removal.

2.03 AUTONOMOUS CONTROL UNIT

A. The autonomous control unit shall be integrated with the building fire alarm control panel to form one combined system that performs both functions (fire alarm and mass notification). The combined system shall meet all requirements within NFPA 72 and shall be listed to UL 864.

B. The autonomous control unit shall have the ability to store, record, and replay multiple digitally recorded messages until silenced. At a minimum, digitally recorded messages shall be created to address the following scenarios:
   1. Emergency weather conditions.
   2. Direct occupants to take cover within the building.
   3. Bomb threat or actual bomb located on or near premises.
   4. Evacuate building using non-standard entrances and exits to avoid dangers at main entrances and exits.
   5. Hostile/Intruding individual outside of the building.
   6. Hostile/Intruding individual inside of the building.
   7. “All clear” conditions.
   8. Test message to verify normal working condition of system.

C. The autonomous control unit shall monitor and control the notification appliance network and provide a console for local operation. The autonomous control unit console shall be capable of providing the following functions:
   1. Initiate delivery of pre-recorded voice messages.
   2. Provide live voice messages and instructions using an integral microphone.
   3. Initiate visual strobe and (optional) textual message notification appliances, where provided.

D. Live voice messages shall have the ability to interrupt the public address system, silence background music, and temporarily override the fire alarm audible messages in progress. Live voice messages shall have the ability to be delivered without initiating building notification visual devices.
   1. All other aspects of the fire alarm system shall function normally and properly during the transmission of live voice messages using the autonomous control unit, and immediately thereafter.

E. The autonomous control unit shall be provided with a single switch or operating mechanism capable of deactivating the system’s fire alarm (white/clear) visual notification appliances and mass notification (amber) visual notification appliances separately.

F. The autonomous control unit shall have the ability to interface with a local operating console for initiating digitally recorded messages and live voice messages from remote locations.

G. The autonomous control unit shall prioritize transmission of messages initiated from the autonomous control unit, wide area notification, and local operating console.

2.04 LOCAL OPERATING CONSOLE

A. The local operating console shall allow operation of the building Mass Notification System. It shall interface with and operate through the autonomous control unit. The local operating console shall be tamper-proof to minimize potential operation by unauthorized personnel.

B. The local operating console shall consist of a [flush] [surface] mounted enclosure located where shown on drawings and approved by the Authority Having Jurisdiction. It shall contain the following:
   1. A local microphone or handset to provide live voice messages.
   2. A means to manually select and activate individual prerecorded messages from the autonomous control unit.
   3. A single switch or operating mechanism capable of deactivating the system's fire alarm (white/clear) visual notification appliances and mass notification (amber) visual notification appliances separately.
   4. LED indication to indicate when the local operating console is in use.
   5. A single switch or operating mechanism capable of shutting down all HVAC equipment in the facility.

2.05 FIRE ALARM SYSTEM ANNUNCIATOR

A. Remote LCD Annunciator:
   1. Annunciator shall consist of a UL listed, supervised, alphanumeric display, remotely located, back-lit LCD display containing a minimum of 80 characters for fire alarm annunciation in English text.
   2. Annunciator shall display all alarm and trouble conditions in the system. Acknowledge, signal silence, test and reset capability shall be locally available at the annunciator.

2.06 SIGNALING LINE CIRCUIT DEVICES

A. Manual Fire Alarm Boxes:
   1. Comply with UL 38.
   2. Boxes shall be directly connected to a SLC loop and finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   3. Double-action mechanism requiring two actions to initiate an alarm pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   4. Station Reset: Key- or wrench-operated switch.

B. Smoke Detectors:
   1. Comply with UL 268.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base in locations shown on drawings with all mounting hardware provided. Provide terminals in the fixed base for connection to building wiring.
   4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   5. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
   6. Photoelectric Smoke Detector: Detector shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

7. Detector shall be directly connected to a SLC loop. Each detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
8. Dual status LEDs shall be provided on each smoke detector to indicate the detector is operational and in regular communication with the control panel, or in an alarm condition.
9. Each detector shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel.

C. Duct Smoke Detectors:
1. Comply with UL 268A.
2. The smoke detector housing shall accommodate an intelligent photoelectric smoke detector having the same features specified for standard smoke detectors with the following additional features required below.
3. Provide sampling tubes and mounting hardware to match the duct to which it is attached. Sampling tube design and dimensions shall be as recommended by manufacturer for specific duct size, air velocity and installation conditions where applied. Where the detector housing is larger than the duct height, the Contractor shall fabricate a mounting bracket for the detector and attach according to the fire alarm manufacturer’s recommendations.
4. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
5. Weatherproof Duct Housing Enclosure for outdoor locations: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
6. Remote Indication: Provide a remote LED indicator device if detector is not visible from a floor standing position. If detector is located above a suspended ceiling, mount remote indicator in ceiling directly below detector with a white single-gang faceplate, labeled to indicate device type and mechanical equipment being monitored.

D. In-Duct Smoke Detectors:
1. The in-duct smoke detector shall have the same features listed under the “Smoke Detectors” section of this specification and listed for in-duct use.
2. Remote Indication: Provide a remote LED indicator device if detector is not visible from a floor standing position. If detector is located above a suspended ceiling, mount remote indicator in ceiling directly below detector with a white single-gang faceplate, labeled to indicate device type and mechanical equipment being monitored.

E. Heat Detectors:
1. Comply with UL 521.
2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 degrees F or a rate of rise that exceeds 15 degrees F per minute unless otherwise indicated.
3. Mounting: Twist-lock base interchangeable with smoke-detector bases. Provide two-piece head/base design.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
5. Device shall connect directly to a SLC loop.
6. Dual status LEDs shall be provided on each smoke detector to indicate the detector is operational and in regular communication with the control panel, or in an alarm condition.
7. Each detector shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel.

2.07 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

B. All wall-mounted audible, visual and combination notification devices shall be white in color, with red lettering. Lettering shall read ALERT.

C. All ceiling-mounted audible, visual and combination notification devices shall be white in color, with red lettering. Lettering shall read ALERT.

D. Audio Speaker Devices 8 inch Diameter Ceiling Mount or Wall Mount):
   1. All speakers shall operate on 25V RMS system, have a minimum frequency range of 400 to 40000Hz, and shall be provided with field selectable output taps available in 3dBA increments.
   2. Speakers in corridors and public spaces shall produce a nominal sound output of 84 dBA at 10 feet.
   3. All speakers shall be capable of reproducing a clear signal consisting of a live or prerecorded voice with intelligibility.

E. High-Range Speaker Units:
   1. Speakers shall operate on 25V RMS system and provided with field selectable output taps. Tap settings shall be capable of producing 2–15-Watt output.
   2. Speakers shall produce a nominal sound output of 108dBA.

F. Exterior (Re-Entrant) Speakers:
   1. Speakers shall operate on 25V RMS system and be provided with a built-in 5 Watt amplifier.
   2. Speakers shall be provided with tap settings to provide a nominal sound output of 110-116dBA with a 300-10,000Hz frequency response.
   3. Provide weatherproof, outdoor rated housing and backbox.

G. Visual Notification Appliances:
   1. Xenon strobe lights or equivalent in compliance with UL 1971 and ADAAG with clear or nominal clear lens for fire alarm systems.
   2. The maximum pulse duration shall be two one-hundredths of one second (0.02 seconds) with a maximum duty cycle of 40 percent. The flash rate shall be 1 Hertz.
   3. Visual alarm notification appliances shall be flash in a temporal pattern and fully synchronized with all other units.
   4. Visual notification appliances utilized in conjunction with carbon monoxide detectors shall be Xenon strobe lights or equivalent in compliance with UL 1971 and ADAAG with clear or nominal clear lens and shall not have the “FIRE” or any fire symbol in any form on the appliance visible to the public.
   5. Rated Light Output:
      a. 15/30/75/110 Candela, selectable in the field, as indicated on drawings.
   6. Mounting: As indicated on drawings.
   7. Strobe Leads: Factory connected to screw terminals.

H. Textual Display Signs
   1. Textual display signs shall be LED with four fixed messages. Sign shall be not exceed 16 inches long by 6 inches high by 3 inches deep with a height necessary to meet the requirements of NFPA 72.
   2. The text display must spell out the words "EVACUATE", "ANNOUNCEMENT", “SHELTER IN PLACE" as appropriate. Final message shall be determined by Owner.
   3. The design of text display must be such that it cannot be read when not illuminated.
   4. Display shall be wall or ceiling mounted.

5. Mounting brackets shall be provided for a convenient wall or partition mount.
6. The system shall interface with the textual display sign control panel to activate the proper message.

I. Combination Audible/Visual Notification Appliances:
1. Single device with integral audible and visual notification, meeting the requirements for each component (audible and visual) per this specification.

2.08 ADDRESSABLE INTERFACE DEVICES

A. Addressable Relays:
1. Addressable relay module available for control of auxiliary devices, rated for the electrical load being controlled. Contractor shall provide additional slave relay(s) as required to achieve desired function.
2. Addressable relays shall connect directly to a SLC loop and receive power from a separate 24VDC circuit. Addressable relay shall supply 24VDC power to the device(s) being controlled, unless otherwise indicated on the drawings.

B. Addressable Monitor Modules:
1. Addressable monitor module available for monitoring of auxiliary devices. It shall interface initiating devices with the fire alarm control panel.
2. Addressable monitor modules shall connect directly to a SLC loop and receive power from a separate 24VDC circuit.
3. The addressable monitor module shall provide the required power to operate the monitored device(s).
4. At the Contractor's option, an integral relay capable of providing a direct signal auxiliary device may be provided within the monitor module.

2.09 MAGNETIC DOOR HOLDERS

A. Description: Units shall be equipped for wall or floor mounting as indicated and shall be complete with matching door plate. Electromagnet operates from a 24V AC 120V AC source and shall require no more than 3 watts to develop 25 pounds holding force.

B. Material and Finish: Match door hardware.
1. Door holders are to be furnished by the general contractor and wired by the electrical contractor.

2.10 NOTIFICATION APPLIANCE CIRCUIT EXTENDER PANELS

A. This Contractor and Vendor shall be responsible for furnishing and installing notification appliance circuit extender panels as necessary to provide remote power supply for notification appliance circuits, based on calculations performed by the Vendor.

B. Notification appliance circuit extender panels may be installed only in back-of-house areas such as janitor, electrical, mechanical and telecommunications closets. Coordinate final locations with Architect/Engineer prior to rough-in where not indicated on drawings. Indicate locations of extender panels on shop drawing submittals.

C. Notification appliance circuit extender panels shall be self-contained remote power supplies with batteries and charger mounted in a surface or recessed lockable cabinet. Manufacturer shall match fire alarm control panel.

D. Battery capacity shall be sufficient for operation for 48 hours of non-alarm state, followed by alarm for 15 minutes.

E. Notification appliance circuit extender panels shall be provided with 25 percent spare capacity for future devices.

F. Power for notification appliance extender panels shall be from a 120VAC circuit supplied by the nearest emergency panelboard. Extend two #12 conductors and 1#12 ground in 1/2 inch

conduit to each notification appliance circuit extender panel from a dedicated 20A, single pole circuit breaker. Provide red handle-lock device for each circuit breaker serving notification appliance extender panels.

2.11 WIRING

A. All fire alarm and mass notification wiring and cables shall be furnished and installed by the Contractor.

B. Wiring shall be in accordance with local, state and national codes. Number and size of conductors shall be as recommended by the fire alarm system manufacturer.

C. All analog voice speaker and analog telephone circuits shall utilize twisted/shielded pair to eliminate cross talk.

D. All wiring and cables shall be UL listed and labeled as complying with NFPA 70 Article 760.

PART 3 - EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Comply with NFPA 70, NFPA 72, local and state codes and manufacturer recommendations for installation of fire-alarm equipment.

B. Devices specified to be surface mounted shall be mounted on a manufacturer provided backbox, painted to match the color of the device. The backbox shall be the same size and shape of the device and must not have visible knockouts.

C. Conduit system and fire alarm/MNS components shall be supported in compliances with Specification Section 13 05 41 “Seismic Restraints.”

D. Fire Alarm Control Panel:
   1. Flush mount the fire alarm control panel plumb in location shown on drawings. All expansion cabinets, if required, shall be located at the fire alarm control panel.

E. Signaling Line Circuit Devices:
   1. General:
      a. Do not install pull stations, fire alarm annunciators and signaling appliances before all dust producing construction in the area has ceased.
      b. Ceiling mounted devices shall be located where shown on the floor plans or reflected ceiling plans. Where a conflict arises with architectural elements or other items that will not allow installation in shown location, the Contractor shall notify the Engineer to coordinate a different acceptable location.
      c. Coordinate the location of all ceiling devices with luminaires, sprinkler heads, piping, diffusers, grilles and other obstructions to maintain a neat and operable operation. Mounting locations and spacing must in accordance with NFPA 72.
      d. Center ceiling mounted devices within each ceiling tile where installed in a grid type ceiling. Devices installed within hard ceilings shall be arranged in a neat and uniform pattern.
   2. Provide a means of isolating addressable devices connected to the SLC so that connection to the devices in no more than one zone would be lost by a single fault on a pathway, per NFPA-72 chapter 23.6.
      a. Zones are designated as each separate floor, by floor area if floor exceeds 22,500 sf, by fire or smoke barrier boundaries, by maximum length or circuit.
   3. Manual Fire Alarm Boxes:
      a. Mount semi-flush in recessed back boxes, installed 48 inches above the finished floor.
   4. Smoke Detectors:
      a. Detector heads shall not be installed until after the final construction cleaning, unless required by the Authority Having Jurisdiction. If detector heads must be

installed prior to final cleaning, they may not be installed until they can be connected to a fully functional fire alarm control panel.

b. All smoke detectors must be installed in an accessible location, including in-duct smoke detectors, and detectors at the top of elevator shafts. Provide access panels as required. Coordinate with General Contractor.

c. Provide a smoke detector at each Fire Alarm Panel and Notification Appliance Circuit Extender Panel location whether shown on drawings or not.

d. Smoke detectors must be located at least 3 feet-0 inches from each supply air diffuser and return grille.

e. Smoke detectors shall be installed at least 12 inches from any part of a lighting fixture.

5. Duct Smoke Detectors:

a. Duct smoke detectors with respective sampling tubes shall be installed on the duct where shown on drawings in compliance with manufacturer's requirements. Sampling tubes shall extend the full width of the duct. All duct penetrations shall be sealed airtight.

b. Duct smoke detectors (or duct mounted smoke detectors) shall have spare set of contacts to provide status of duct detector to BAS system and alarm upon activation of duct mounted smoke detector.

6. Heat Detectors:

a. Detector heads shall not be installed until after the final construction cleaning, unless required by the Authority Having Jurisdiction. If detector heads must be installed prior to final cleaning, they may not be installed until they can be connected to a fully functional fire alarm control panel.

b. All heat detectors must be installed in an accessible location.

c. Provide heat detectors within 2 feet-0 inches of each sprinkler head within elevator pit, elevator shaft and elevator equipment room. Final quantity of sprinkler heads and respective locations must be coordinated with Fire Protection Contractor.

d. Heat detectors shall be installed at least 12 inches from any part of a lighting fixture.

e. All heat detectors must be installed in an accessible location, including and detectors at the top of elevator shafts. Provide access panels as required. Coordinate with General Contractor.

F. Notification Appliance Devices:

1. Devices shall be located where shown on drawings.

2. Wall mounted devices shall be installed on flush-mounted backboxes.

3. Ceiling mounted devices shall be installed flush with ceiling, centered within ceiling tile if installed in a grid-type system. Devices installed within hard ceilings shall be arranged in a neat and uniform pattern.

4. Where devices are to be installed in a location having a ceiling exceeding a 30 foot-0 inch height, provide stem-mounting device and support hardware, installed such that the entire device is below 30 feet-0 inches.

G. Addressable Interface Devices:

1. Addressable Relays:

a. Mount each addressable relay within an enclosure located in an accessible serviceable area as near as possible to the device(s) being controlled unless otherwise specifically noted. Provide all required mounting hardware and label each enclosure to indicate relay function. Provide remote indicator to allow inspection of the device status from a floor standing location if device is not visible from a floor standing position.

2. Addressable Monitor Modules:

a. Mount each addressable monitor module within an enclosure located in an accessible serviceable area as near as possible to the device(s) being controlled unless otherwise specifically noted. Provide all required mounting hardware and label each enclosure to indicate device being monitored. Provide remote indicator to allow inspection of the device status from a floor standing location if device is not visible from a floor standing position.

H. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

I. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.02 ANNUNCIATORS

A. Install and arrange as indicated, located where shown on drawings and approved by the Fire Marshal.

3.03 WIRING

A. Fire alarm and mass notification wiring shall be provided by the Contractor in accordance with the manufacturer’s recommendations and in compliance with the National Fire Codes.

B. Connect all components together for a completely functional ready to operate system as shown on the drawings, as specified herein and as directed by the manufacturer.

C. Install all fire alarm wiring in conduit.
1. Wiring not associated with fire alarm detection, alarm or auxiliary fire protection functions shall not be routed in fire alarm conduits.

D. Fire alarm wiring splices shall be avoided to the extent possible. If needed, splices may only be made in accessible junction boxes, compliant with NFPA 70.

E. Notification appliance circuits shall not span floors.

F. Signal line circuits connecting devices shall not span floors.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Paint all junction boxes associated with the fire alarm system red. Identify SLC and NAC circuit on junction box cover.

C. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Differentiate the following circuit types by using different conductor colors with an overall red jacket.
1. Alarm Circuits.
2. Supervisory Circuits.
3. Initiating Circuits.
4. Notification Circuits.
5. Door Release.
6. Central Station.
7. DC Power Supply.
8. Power Branch Circuits.

3.05 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100 and manufacturer written requirements. Install a ground wire from main service ground to fire alarm control unit.

B. For audio circuits, minimize the following to the greatest extent possible: ground loops, common mode returns, noise pickup, cross talk and other impairments.

3.06 SEQUENCES OF OPERATION

A. General:
   1. Refer to the Fire Alarm and Mass Notification Operation Matrix within the drawings for basic requirements and system input/output relationships.

B. Panel/Annunciator Alarm, Trouble, Supervisory Indication:
   1. Respective system Alarm, Trouble or Supervisory LED indicator light shall cycle on/off at the following locations:
      a. Fire Alarm Control Panel.
      b. Remote Annunciator Locations.
      c. Fire Alarm Transponder.
   2. Appropriate signal shall be transmitted to the central station via the digital communicator.
   3. Event date, time and type of occurrence shall be recorded within the Fire Alarm Control Panel event history.

C. Fire Alarm Visual Alarm Sequence:
   1. Visual alarms throughout the building shall flash. Strobes within the building shall be synchronized.

D. Fire Alarm Audible Alarm Sequence:
   1. Audible alarms throughout the building shall sound.

E. Air Handling Unit Shutdown Sequence:
   1. Utilizing addressable relays, the fire alarm system shall directly shut down the air handling units through each unit's local motor controller.
   2. All air handling units shall simultaneously shutdown throughout the building.
   3. Once alarm state has been reset, air handling units shall automatically be re-energized and resume normal operation.

F. Smoke Damper Sequence:
   1. Utilizing an addressable relay, the power connection to smoke and/or fire/smoke dampers shall be interrupted, allowing them to close. Coordinate all interconnection requirements with the mechanical contractor.
   2. In the event a smoke damper is located in a main air duct and closure of this damper will completely block airflow to the ductwork system being served by that particular air handling unit, the smoke damper sequence shall also initiate the air handling unit shutdown sequence for that unit.
   3. If all of the smoke and/or fire/smoke dampers associated with a particular air handling unit are closed, the air handling unit shutdown sequence shall be initiated for that unit.
   4. All smoke and/or fire/smoke dampers shall be closed throughout the building.

G. Door Holder Release Sequence:
   1. Utilizing an addressable relay, the power connection to magnetic door holders and/or 'hold' switch circuitry within door hardware shall be interrupted, allowing doors to close.
   2. Door holders shall be released individually based on the location of the alarming device specifically designated for that door.

H. Fire Protection Electric Sprinkler Bell Sequence:
   1. Utilizing an addressable relay, the electric sprinkler bell shall activate upon water flow detection through flow switches.

I. Dry-Pipe Sprinkler Activation Sequence:
   1. Utilizing addressable monitor modules, the fire alarm system shall monitor the status of the dry-pipe sprinkler system. Provide a separate monitor module to monitor the contacts for alarm, trouble, supervisory, power and any additional contacts required to be monitored for the pre-action system installed.

2. Coordinate all programming and hardware requirements with the fire protection contractor.

J. Kitchen Hood Fire Suppression Sequence:
   1. Utilizing an addressable relay, the fire alarm system shall de-energize the hood supply fan controller.
   2. Utilizing an addressable monitor module, the fire alarm system shall monitor the fire suppression system.

K. Elevator Recall Sequence:
   1. Elevator recall sequences shall meet all of the requirements listed within ASME/ANSI A17.1 (latest version) and NFPA 72 (latest version).
   2. An alarming smoke detector within the elevator hoistway, machine room or elevator lobby (other than the 'designated level') shall signal the elevator controller to recall the elevator cab to the 'designated level' as determined by the Authority Having Jurisdiction using an addressable relay.
   3. An alarming smoke detector within the elevator lobby of the 'designated level' shall signal the elevator controller to recall the elevator cab to the 'alternate level' as determined by the Authority Having Jurisdiction using an addressable relay.

L. Firefighter's Warning Light Sequence:
   1. Utilizing an addressable relay, a signal shall be sent to the elevator controller to illuminate the firefighter's warning light within the elevator cab.

M. Elevator Shutdown Sequence:
   1. Elevator shutdown shall meet all of the requirements listed within ASME/ANSI A17.1 (latest version) and NFPA 72 (latest version).
   2. Utilizing an addressable relay, an alarming heat detector within the elevator hoistway or machine room shall send a signal to shunt trip the main elevator circuit breaker, disconnecting power to the elevators.
   3. Only elevators utilizing a common hoistway, machine room or lobby shall be simultaneously shut down. All other elevators shall remain operational.

N. Elevator Hoistway Damper Sequence:
   1. Each elevator shaft damper shall be controlled to meet all of the requirements listed within ASME/ANSI A17.1 (latest version) and NFPA 72 (latest version).
   2. Utilizing an addressable relay, the fire alarm system shall open or close the elevator shaft damper from a manually operated switch. Provide switch within the Fire Alarm Control Panel, or directly adjacent to it within a separate enclosure, painted red and labeled for use.
   3. Fire alarm system shall provide status indication of each hoistway damper position (open or closed) at the fire alarm control panel and annunciators.

O. Mass Notification Audible Alarms:
   1. Audible alarms throughout the building shall sound with the associated pre-recorded message.
   2. The fire alarm system, if in an alarming state, shall be temporarily deactivated during a mass notification event.

P. Mass Notification Visual Alarms:
   1. Visual alarms designated for Mass Notification throughout the building shall flash. Strobes within the building shall be synchronized.
   2. The fire alarm system, if in an alarming state, shall be temporarily deactivated during a mass notification event.

3.07 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Owner's representative and authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Test fire alarm system in accordance with NFPA 72 Chapter 14, local Fire Marshal requirements and local building codes.
   2. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   3. Contractor shall test and adjust the voice fire alarm system after all furnishings, wall and floor coverings and fixed equipment is in place and operating. Measurements should be taken at a height of five feet above the finished floor level.
      a. Adjust speaker taps to the lowest tap setting that achieves a sound level higher than or equal to the following:
         1) 15dBA above ambient levels as indicated in NFPA 72 table A.18.4.3
         2) 15dBA above measured ambient. 5dBA above the maximum measured sound level with duration of more than 60 seconds.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Contractor and Owner shall coordinate actual room numbers to be used within facility. Final room numbers should be used for fire alarm system programming and record documents.

3.08 SYSTEM TRAINING

A. Authorized manufacturer representative shall provide the following minimum on-site training to instruct the Owner’s representative as required for operating the system. Hands-on demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.
   1. System Operators: One day.

B. The contractor and/or the system manufacturer’s representatives shall provide a typewritten “Sequence of Operation.”

END OF SECTION

SECTION 31 10 00

SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Stripping and stockpiling rock.
6. Removing above- and below-grade site improvements.
7. Disconnecting, capping or sealing, and removing site utilities.
8. Temporary erosion and sedimentation control.

1.3 DEFINITIONS

A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated on Drawings.

F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.6 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or video recordings.

B. Topsoil stripping and stockpiling program.

C. Rock stockpiling program.

D. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

E. Burning: Documentation of compliance with burning requirements and permitting of authorities having jurisdiction. Identify location(s) and conditions under which burning will be performed.

1.7 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises as directed by the Owner.

D. Utility Locator Service: Notify One Call, Missouri One Call (1-800-DIG-RITE) for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place.

F. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."

G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 31 20 00 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

B. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.

1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities.

2. Owner will arrange to shut off indicated utilities when requested by Contractor.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without Architect's written permission.

E. Excavate for and remove underground utilities indicated to be removed.

F. Removal of underground utilities is included in earthwork sections; in applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security, and utilities sections; and in Section 02 41 16 "Structure Demolition" and Section 02 41 19 "Selective Demolition."

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.

2. Grind down stumps and remove roots larger than 3 inches in diameter, obstructions, and debris to a depth of 18 inches below exposed subgrade.

3. Use only hand methods or air spade for grubbing within protection zones.

4. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth indicated on Drawings in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 STOCKPILING ROCK

A. Remove from construction area naturally formed rocks that measure more than 1 foot across in least dimension. Do not include excavated or crushed rock.

1. Separate or wash off non-rock materials from rocks, including soil, clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

B. Stockpile rock away from edge of excavations without intermixing with other materials. Cover to prevent windblown debris from accumulating among rocks.

1. Limit height of rock stockpiles to 36 inches.

2. Do not stockpile rock within protection zones.

3. Dispose of surplus rock. Surplus rock is that which exceeds quantity indicated to be stockpiled or reused.

3.8 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.

2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Burning tree, shrub, and other vegetation waste is permitted according to burning requirements and permitting of authorities having jurisdiction. Control such burning to produce the least smoke or air pollutants and minimum annoyance to surrounding properties. Burning of other waste and debris is prohibited.

C. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 10 00

SECTION 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating and filling for rough grading the Site.
2. Preparing subgrades for slabs-on-grade, walks, turf and grasses, and plants.
3. Preparing improved subgrades for pavements,
4. Excavating and backfilling for buildings and structures.
5. Drainage course for concrete slabs-on-grade.
6. Subbase course for concrete walks and pavements.
7. Subbase course and base course for asphalt paving.
8. Subsurface drainage backfill for walls and trenches.
9. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Requirements:

1. Section 31 10 00 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
2. Section 32 92 00 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
3. Section 32 93 00 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

1.2 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.

3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, will be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock:

1. Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or 3/4 cu. yd. for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
   a. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch-maximum-width, short-tip-radius rock bucket; rated at not less than 138-hp flywheel power with bucket-curling force of not less than 28,700 lbf and stick-crowd force of not less than 18,400 lbf with extra-long reach boom.
   b. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-hp flywheel power and developing a minimum of 47,992-lbf breakout force with a general-purpose bare bucket.

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other fabricated stationary features constructed above or below the ground surface.

J. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

L. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct preexcavation conference at Project site.

1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
   a. Personnel and equipment needed to make progress and avoid delays.
   b. Coordination of Work with utility locator service.
   c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
   d. Extent of trenching by hand or with air spade.
   e. Field quality control.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geotextiles.

2. Controlled low-strength material, including design mixture.

3. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:

1. Geotextile: 12 by 12 inches.

2. Warning Tape: 12 inches long; of each color.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D2487.

2. Laboratory compaction curve according to ASTM D698.

C. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

1.6 QUALITY ASSURANCE

1.7 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify "One Call" Missouri One call (1-800-DIG-RITE) for area where Project is located before beginning earth-moving operations.

D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 311000 "Site Clearing" are in place.

E. Do not commence earth-moving operations until plant-protection measures specified in Section 01 56 39 "Temporary Tree and Plant Protection" are in place.

F. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.

2. Parking vehicles or equipment.

3. Foot traffic.

4. Erection of sheds or structures.

5. Impoundment of water.

6. Excavation or other digging unless otherwise indicated.

7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

G. Do not direct vehicle or equipment exhaust towards protection zones.

H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups CL, ML, CL-ML, SW, and GW according to ASTM D2487 and Geotechnical Report, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, OL, CH, MH, OH, and PT according to ASTM D2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.

I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and zero to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C33/C33M; fine aggregate.

K. Prepared Subgrade (unimproved): Prepare Subgrade according to the applicable Articles in Section 209 of the Missouri Department of Transportation's "Standard Specifications for Highway Construction" and per the subgrade inspection.

L. Prepared Subgrade (improved): Satisfactory soil under road and parking lot pavements that are stable, compacted, and able to react with lime for lime stabilization (Plasticity Index >10). Thoroughly mix in hydrated lime at an estimated rate of 5 percent, adjustments to the application rate may be required based on field conditions and as approved by the Engineer. Prepare subgrade according to Article 205 of the Missouri Department of Transportation's "Standard Specifications for Highway Construction".

2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability:
   a. Class 2; AASHTO M 288.
   b. Apparent Opening Size: As indicated on drawing sieve, maximum; ASTM D4751.
   c. Permittivity: 0.5 per second, minimum; ASTM D4491.
   d. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability:
   a. Class 2; AASHTO M 288.
   b. As follows:
      1) Grab Tensile Strength: 247 lbf; ASTM D4632.
      2) Sewn Seam Strength: 222 lbf; ASTM D4632.
      3) Tear Strength: 90 lbf; ASTM D4533.
      4) Puncture Strength: 90 lbf; ASTM D4833.
   c. Apparent Opening Size: No. 60 sieve, maximum; ASTM D4751.
   d. Permittivity: 0.02 per second, minimum; ASTM D4491.
   e. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting, flowable concrete material produced from the following:

1. Portland Cement: ASTM C150/C150M, Type I

2. Fly Ash: ASTM C618, Class C or F.

3. Normal-Weight Aggregate: ASTM C33/C33M, 3/8-inch nominal maximum aggregate size.

4. Foaming Agent: ASTM C869/C869M.

5. Water: ASTM C94/C94M.

6. Air-Entraining Admixture: ASTM C260/C260M.

B. Produce conventional-weight, controlled low-strength material with 80-psi compressive strength when tested according to ASTM C495/C495M.

2.4 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:

1. Red: Electric.

2. Yellow: Gas, oil, steam, and dangerous materials.

3. Orange: Telephone and other communications.

4. Blue: Water systems.

5. Green: Sewer systems.

B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.

2. Yellow: Gas, oil, steam, and dangerous materials.

3. Orange: Telephone and other communications.

4. Blue: Water systems.

5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Provide dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

D. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

3.3 EXPLOSIVES

A. Explosives:

1. Do not use explosives.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
   a. 24 inches outside of concrete forms other than at footings.
   b. 12 inches outside of concrete forms at footings.
   c. 6 inches outside of minimum required dimensions of concrete cast against grade.
   d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
   e. 6 inches beneath bottom of concrete slabs-on-grade.
   f. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe or 42 inches wide.

B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for authorized additional rock excavation according to Contract provisions for changes in the Work. Changes in the Contract Time may be authorized for rock excavation.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.
   a. Intermittent drilling; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:
   a. 24 inches outside of concrete forms other than at footings.
   b. 12 inches outside of concrete forms at footings.
   c. 6 inches outside of minimum required dimensions of concrete cast against grade.
   d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
   e. 6 inches beneath bottom of concrete slabs-on-grade.
   f. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe or 42 inches wide.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

2. Pile Foundations: Stop excavations 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.

3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

2. Cut and protect roots according to requirements in Section 01 56 39 "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit as indicated.

C. Trench Bottoms:

1. Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
   a. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
   b. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
   c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
   d. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

2. Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
   a. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.8 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.

B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.

2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.

2. Surveying locations of underground utilities for Record Documents.

3. Testing and inspecting underground utilities.

4. Removing concrete formwork.

5. Removing trash and debris.

6. Removing temporary shoring, bracing, and sheeting.

7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 03 30 00 "Cast-in-Place Concrete."

D. Trenches under Roadways: Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 12 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 03 30 00 "Cast-in-Place Concrete."

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Initial Backfill:

1. Soil Backfill: Place and compact initial backfill of bedding course, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
   a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

2. Controlled Low-Strength Material: At the Contractor’s options place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.

G. Final Backfill:

1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.

2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

H. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.

2. Under walks, use prepared subgrade

3. Under pavements, except pervious concrete, prepared subgrade (improved)

4. Under steps and ramps, use engineered fill.

5. Under building slabs, use engineered fill.

6. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D698:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.

2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.

3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.

4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.

2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.

2. Walks: Plus or minus 1/4 inch.

3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.17 SUBSURFACE DRAINAGE

A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.

B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.

2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade (improved) and prepared subgrade, place subbase course and base course under pavements and walks as follows:

1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.

2. Place base course material over subbase course under hot-mix asphalt pavement.

3. Shape subbase course and base course to required crown elevations and cross-slope grades.

4. Place subbase course and base course 6 inches or less in compacted thickness in a single layer.

5. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.

6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D698.

C. Subbase and base course under pervious pavement shall be in accordance with 32 13 43 Pervious Concrete Paving.

3.19 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.

2. Place drainage course 6 inches or less in compacted thickness in a single layer.

3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.

4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D698.

3.20 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.

2. Determine that fill material classification and maximum lift thickness comply with requirements.

3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. Testing agency will test compaction of soils in place according to ASTM D1556, ASTM D2167, ASTM D2937, and ASTM D6938, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.

2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length but no fewer than two tests.

3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length but no fewer than two tests.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.21 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00

SECTION 32 13 13

CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes concrete paving including the following:
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.
   6. Utility pads.

B. Related Requirements:
   1. Section 03 30 00 "Cast-in-Place Concrete" for general building applications of concrete.
   2. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
   3. Section 32 17 13 "Parking Bumpers."
   4. Section 32 17 23 "Pavement Markings."
   5. Section 32 17 26 "Tactile Warning Surfacing" for detectable warning tiles.

C. Related Documents:
   1. Missouri Standard Specifications for Highway Construction. Latest edition.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.
   2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Environmental Product Declaration (EPD): For each product.
3. Laboratory Test Reports: For concrete paving mixtures, documentation indicating that cured concrete complies with Solar Reflectance Index requirements.

C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

D. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:
1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Admixtures.
4. Curing compounds.
5. Applied finish materials.
6. Bonding agent or epoxy adhesive.
7. Joint fillers.

C. Material Test Reports: For each of the following:

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.
1. Personnel conducting field tests must be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.8 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
   1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
   2. Do not use frozen materials or materials containing ice or snow.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
   1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
   3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
   1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet. Steel Reinforcement shall be as indicated on the plan drawings and in accordance with the Missouri Standard Specifications for Highway Construction.

2.4 CONCRETE MATERIALS

A. Regional Materials: Verify concrete is manufactured within 100 miles of Project site from aggregates and cementitious materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

B. Concrete: Provide Portland cement concrete in accordance with the Missouri Standard Specifications for Highway Construction.

C. Comply with slump, air entrainment, strength, and material composition requirements.

D. Admixtures: All admixtures shall be approved by the Architect.

E. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.
   1. Color: As selected by Architect from manufacturer's full range.

F. Water: Potable and complying with ASTM C94/C94M.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.

B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

2.6 RELATED MATERIALS

A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber in preformed strips.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

C. Bonding Agent: ASTM C1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy-Bonding Adhesive: ASTM C881/C881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
   1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch.

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
   1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
   2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.

B. Cementitious Materials shall be in accordance with the Missouri Standard Specifications for Highway Construction.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as indicated in the Missouri Standard Specifications for Highway Construction.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions and in accordance with the Missouri Standard Specifications for Highway Standards.
   1. Solar Reflectance (SR): Three-year-aged SR value of at least 0.28 or initial SR of at least 0.33.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to the Missouri Standard Specifications for Highway Construction. Furnish batch certificates for each batch discharged and used in the Work.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
   1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
   2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
   3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll subbase in one direction. Limit vehicle speed to 3 mph.
   2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 31 20 00 "Earth Moving."

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

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 INSTALLATION OF STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D3963/D3963M.

F. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
   1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
   1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
   2. Provide tie bars at sides of paving strips where indicated.
   3. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
   4. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
   1. Locate expansion joints at intervals of 30 feet unless otherwise indicated.

2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving:
1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
a. Tolerance: Ensure that sawed joints are within 3 inches either way from centers of dowels.
2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 3/8-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Place, finish, and cure all concrete pavements according to the applicable requirements of the Missouri Standard Specifications for Highway Construction.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
1. Finish texture shall conform to the requirements of the Missouri Standard Specifications for Highway Construction.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by curing compound as follows:
   1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
   1. Elevation: 1/2 inch.
   2. Thickness: Plus 3/8 inch, minus 1/4 inch.
   3. Surface: Gap below 10-feet-long; unleveled straightedge not to exceed 1/4 inch.
   4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
   5. Lateral Alignment and Spacing of Dowels: 1 inch.
   6. Vertical Alignment of Dowels: 1/4 inch.
   7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
   8. Joint Spacing: 3 inches.
   9. Contraction Joint Depth: Plus 1/4 inch, no minus.
   10. Joint Width: Plus 1/8 inch, no minus.

B. All sidewalks constructed shall be ADA compliant according to 2010 Americans with Disabilities Act. Any constructed sidewalk not meeting ADA requirements shall be removed and replaced at the Contractor’s expense. If an ADA issue is found in the field, the Contractor shall bring it to the attention of the Architect. The Contractor shall cooperate with the Architect to develop a solution within 2-working days at no additional cost to the contractor.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C172/C172M will be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or 5000 sq. ft. or fraction thereof of each concrete mixture placed each day.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
   5. Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
   6. Compressive-Strength Tests: ASTM C39/C39M; test one specimen at seven days and two specimens at 28 days.
      a. A compressive-strength test to be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results to be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests to contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency will make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.11 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

SECTION 32 13 43

PERVIOUS CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Pervious Concrete Pavement.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.
   2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
   1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
   2. Environmental Product Declaration (EPD): For each product.
   3. Laboratory Test Reports: For concrete paving mixtures, documentation indicating that cured concrete complies with Solar Reflectance Index requirements.

C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

D. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:
   1. Cementitious materials.
   2. Steel reinforcement and reinforcement accessories.
   3. Admixtures.
   4. Curing compounds.
   5. Applied finish materials.
   6. Bonding agent or epoxy adhesive.
   7. Joint fillers.

C. Material Test Reports: For each of the following:

D. Field quality-control reports.

1.2 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities".
   2. Manufacturer shall be pre-qualified by MSD (St. Louis Metropolitan Sewer District)
   3. The name of the producer and their facility location shall be provided to the MSD division inspector prior to construction.

B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.
   1. Personnel conducting field tests must be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

   2. Field Technicians. Provide field technicians meeting one of the following criteria:

      a. Provide at least one National Ready Mixed Concrete Association (NRMCA) certified pervious concrete craftsman on site, overseeing each placement crew during all concrete placement.

      b. Provide no less than three NRMCA certified pervious concrete installers on site working as members of each placement crew during all concrete placement.

C. No product or material substitutions are permitted unless previously approved by the MSD plan review engineer or by the MSD Field Inspector assigned to the project. All substitution for the pervious concrete pavement system shall be presented to MSD through the Engineer.

1.3 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on pervious concrete paving mixtures.

1.4 DELIVERY AND STORAGE

A. In accordance with ACI 522.1 (2013) Specification For Pervious Concrete Pavement

1.5 ACCEPTANCE

A. Tolerances

Acceptance of pervious concrete paving is based on compliance with the tolerances presented in Table 1. Remove and replace pervious concrete paving represented by the failing tests or submit repair plan for approval.

TABLE 1	
Attribute	Tolerance
TEST SECTION	
Fresh Density	plus/minus 5 lb/cf of approved mix design value
Core Length (avg 3)	plus 1.5 inches

Core Length (ind)	minus 3/4 inch
FRESH CONCRETE	
Fresh Density	plus/minus 5 lb/cf of approved mix design value
FINISHED PAVEMENT	
Core Length (avg 3)	plus 1.5 inches
Core Length (ind)	minus 3/4 inch
Hardened Density	plus/minus 5 percent of test section value
Grade	plus/minus 0.05 foot from plan
Grade at	plus 1/8 to 1/4 inch above plan
Smoothness	1/4 inch longitudinal and transverse
Surface Finish	Free of irregularities, tears, and discontinuities

A. Test Section

Construct a minimum 400 square feet test section to demonstrate typical joints, surface finish, texture, color, infiltration rate, thickness, density, and standard of workmanship. Place test section using the mixture proportions, materials, and equipment as proposed for the project. Test in accordance with requirements in subpart FIELD QUALITY CONTROL. When a test section does not meet one or more of the tolerances in Table 1, remove and replace the test section. If the test section is acceptable, it may be incorporated into the project.

PART 2 PRODUCTS

2.1 MATERIALS

A. Cementitious Materials

Provide cementitious materials consisting of portland cement, blended cement or only portland cement in combination with supplementary cementitious materials (SCM), that conform to appropriate specifications listed below. New submittals and preapproval from the Engineer and MSD are required when the cementitious materials sources or types change.

1. Portland Cement

ASTM C150, ASTM C1157, Type I or II.

2. Blended Cement

Provide blended cement conforming to ASTM C595, ASTM C1157, Type IP or IS, including the optional requirement for mortar expansion. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include in written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 percent by mass of the finished cement from lot to lot or within a lot. Do not permit the percentage and type of mineral admixture used in the blend to change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT do not apply to the SCM content of blended cement.

3. Fly Ash and Pozzolan

ASTM C618, Type F or N, including the optional requirement for uniformity, with a loss on ignition not exceeding 3 percent. Provide Class F fly ash for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 3 percent.

a. The strength activity index at 28 days of age of at least 95 percent of the control

specimens.

b. The average particle size not exceeding 6 microns.

4. Slag

ASTM C989, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120.

5. Supplementary Cementitious Material (SCM) Content

Use of one of the SCMs listed below is optional, unless the SCM is required to mitigate ASR.

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
$SiO_2 + Al_2O_3 + Fe_2O_3$ greater than 70 percent	25	35
$SiO_2 + A1_2O_3 + Fe_2O_3$ greater than 80 percent	20	35
$SiO_2 + A1_2O_3 + Fe_2O_3$ greater than 90 percent	15	35
UFFA and UFP	7	16
Slag Cement	40	50

C. Water

Water conforming to ASTM C1602.

D. Aggregates

1. Durability

Evaluate and test all aggregates to be used in all concrete for durability in accordance with ASTM C88. Provide fine and coarse aggregates with a maximum of 18 percent loss when subjected to 5 cycles using Magnesium Sulfate or a maximum of 12 percent loss when subjected to 5 cycles using Sodium Sulfate.

2. Alkali Reactivity Test

Evaluate the fine and coarse aggregates separately, using ASTM C1260. Reject individual aggregates with test results that indicate an expansion of greater than 0.10 percent at 16 days after casting, or perform additional testing as follows: utilize the proposed low alkali portland cement, blended cement, and SCM in combination with each individual aggregate in accordance with ASTM C1567. Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.10 percent at 16 days after casting. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity. If any of the above options does not lower the expansion to less than 0.10 percent at 16 days after casting, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for

evaluation and acceptance.

3. Fine Aggregates

Provide fine aggregate conforming to the quality and grading requirements of ASTM C33.

4. Coarse Aggregates

Provide coarse aggregate consisting of crushed or uncrushed gravel, crushed stone, or a combination thereof meeting the requirements of ASTM C33. Deliver aggregates to the mixers consisting of clean, hard, uncoated particles. Wash aggregate sufficient to remove dust and other coatings.

a. Gradation: ASTM C33,#67.

b. Quality: ASTM C33, Class 4S.

E. Chemical Admixtures

1. Water Reducing and Retarding Admixtures

ASTM C494: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water reducing and accelerating. Acceptance is based on 28 day physical properties. Do not use calcium chloride admixtures.

2. Air Entraining Admixture

Air entraining admixture conforming to ASTM C260.

3. Hydration Retarding Admixture

Hydration retarding admixture conforming to ASTM C494, Type B, retarding, or Type D, water-reducing and retarding.

F. Curing Materials

1. Polyethylene Sheet

Provide curing materials conforming to ASTM C171, 0.006 inch clear or white opaque polyethylene cut to a minimum of 24 inches wider than full placement width, for curing of pervious concrete.

G. Edge Restraints

Provide edge restraints consisting of concrete curb sections and concrete pavement as shown on the plans.

H. Riser Strips

Provide wood strips of thickness to accommodate the initial strike off and consolidation of the pervious concrete.

I. Fiber Reinforcement
1. Synthetic Fiber, Monofilament Fibers: Monofilament polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches long.

2. Synthetic Fiber, Fibrillated Fibers: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches long.

2.2 MIX DESIGN

Design pervious concrete mix in accordance with ACI 522.1 to meet the following criteria: the water/cementitious materials ratio within the range of 0.26-0.40 and the air voids of freshly mixed pervious concrete within the range of 18 to 22 percent, as measured in accordance with ASTM C1688/C1688M. Provide air entrainment in freeze-thaw environments. Provide system with a minimum initial Solar Reflectance of at least 0.33 as tested in accordance with ASTM C1549.

A. Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and include test results demonstrating that the proposed mixture proportions produce pervious concrete of the qualities indicated. Submit test results in a mix design report to include:

a. Aggregate gradations and plots.

b. Aggregate quality test results, including deleterious materials and ASR tests.

c. Mill certificates for cement and supplemental cementitious materials.

d. Certified test results for all admixtures.

e. Recommended proportions and volumes for proposed mixture.

f. Water/cementitious materials ratio and air voids.

g. Narrative discussing methodology on how the mix design was developed.

B. Mix Verification

Mix verification tests may be performed by the Government. Provide quantities of cementitious materials, aggregates and admixtures as requested. Verification tests may be conducted on the proposed mix design proportions to confirm the fresh concrete air voids content. An existing mix design may be submitted if developed within the previous 12 months.

2.3 EQUIPMENT

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times.

A. Compaction Equipment

1. Pipe Roller

A steel pipe roller or a motorized or hydraulically actuated rotating tube screed spanning the width of the section placed.

2. Plate Compactor

Compact small areas using a standard soil plate compactor that has a base area of at least two

square feet and exerts a minimum of 10 psi vertical pressure on the pavement surface (through a temporary cover of 19 mm 3/8 inch thick plywood).

B. Vibratory Screed

Truss mounted vibratory screed, adjustable in length to span the paving lane. Provide capability to adjust the vibration along the screed length and compact the full depth of the pervious concrete thickness.

C. Jointing Tool

Provide a jointing tool consisting of a "pizza cutter roller" to which a beveled fin with a minimum depth of 1/4 the thickness of the slab has been welded around the circumference of a steel roller.

D. Concrete Saw

Provide equipment for sawing joints and for other sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. Provide spares as required to maintain the required sawing rate.

E. Straightedge

Furnish one 12 foot straightedge constructed of aluminum or magnesium alloy, having blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide handles for operation on the pavement.

PART 3 EXECUTION

3.1 PREPARATION FOR PERVIOUS PAVING

A. Verify the underlying material, upon which pervious concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Correct soft, yielding areas and ruts or other irregularities in the surface. Loosen material in the affected areas and remove unsatisfactory material. Add approved select material where directed. Shape the area to line, grade, and cross section, and compact to the specified density. Conform Subgrade to Section 31 00 00 EARTHWORK AND SUBBASE Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the pervious concrete placement.

B. Subgrade Preparation

a. Conduct an ASTM D3385 test to determine the soil condition. Remediate/scarify to improve infiltration as needed.

b. Existing subgrade under stormwater detention layer areas shall not be compacted or subject to excessive construction equipment traffic prior to coarse aggregate bed placement and may be scarified to improve infiltration rates.

c. Cuts necessary to establish proper subgrade level shall not be compacted or be subject to excessive construction equipment traffic prior to coarse aggregate bed placement and may be scarified to improve infiltration rates.

d. When fill is needed to establish proper subgrade level compact to 92% proctor.

e. Fill and lightly re-grade any areas damaged by erosion, ponding, or traffic compaction before the placing of filter fabric and coarse aggregate.

C. Installation of Filter Fabric and Storage Layer

a. Upon completion of subgrade preparation, the Architect/Engineer shall be notified.

b. Filter fabric layer and stormwater reservoir storage aggregate shall be placed immediately after approval of subgrade preparation. Remove any accumulation of debris or sediment prior to installation of filter fabric.

c. Place geotextile filter fabric in accordance with manufacturer's standards and recommendations. Adjacent strips of filter fabric shall overlap a minimum of 16 in. The filter shall be placed on the floor of the excavation and up the sides, directly over the soil subbase and under the coarse aggregate storage layer. The contractor shall secure fabric at least 2 ft outside of bed and take steps necessary to prevent any runoff or sediment from entering the storage bed.

d. Install coarse aggregate in 6 inch maximum lifts. Lightly compact each layer with equipment, keeping equipment movement over storage bed subgrade to a minimum. Install aggregate to grades required on the drawings.

3.2 WEATHER LIMITATIONS

A. Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing pervious concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. Immediately cover and protect all unhardened concrete from the rain or other damaging weather. Completely remove and replace any area damaged by rain or other weather full depth.

B. Cold Weather

Do not place concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours without approval. If approval is granted, heat concrete materials so that the temperature of the concrete at placement is between 65 and 80 degrees F. Methods of heating materials are subject to approval. Do not use heated mixing water. Follow practices found in ACI 306.1.

C. Hot Weather

Maintain required concrete temperature in accordance with ACI 305.1 to prevent evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. After placement, use fog spray or other suitable means to reduce the evaporation rate. Start curing within 20 minutes of concrete discharge. Cool underlying material by sprinkling lightly with water before placing concrete.

3.3 CONCRETE PRODUCTION

Batch, mix, and deliver pervious concrete in accordance with ACI 522.1.

3.4 PAVING

A. Paving Plan

Submit for approval a paving plan identifying the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints.

c. Plan and equipment proposed to control alignment of formed or sawn joints within the specified tolerances.

B. Placing

Comply with guidelines set in ACI 522.1 for placement of pervious concrete, except as modified herein. Do not exceed a free vertical drop of 5 feet. Deposit concrete either directly from the transporting equipment or by conveyor onto the pre-wetted subgrade or subbase, unless otherwise specified. Do not place concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Do not allow foot traffic on the fresh concrete. Place concrete continuously at a uniform rate, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected. Spread the concrete using a come-along, square ended shovel, or rake. Strike off the concrete between forms using a vibrating screed. Other strike off devices may be submitted for Government approval. Remove riser strips immediately after strike off operations are complete.

C. Fixed Form Paving

Use steel forms, except that wood forms may be used for curves having a radius of 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. Provide forms with the base width of the form not less than eight-tenths of the vertical height of the form, except that for forms 8 inches or less in vertical height, provide forms with a base width not less than the vertical height of the form. Provide wood forms for curves and fillets that are adequate in strength and rigidly braced. Provide forms and anchors suitable to resist lateral pressures from compaction. Set forms on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Do not set forms on blocks or on built-up spots of underlying material. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved. Maintain forms in place at least 12 hours after the concrete has been placed. Remove forms without damaging the concrete.

D. Operation

When paving between or adjacent to previously constructed pavement, make provisions to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of any debris.

E. Compaction

Automatically control surface vibration so that it stops immediately as forward motion ceases. Do not permit excessive vibration. Tamp concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment. Do not use vibrators to transport or spread the concrete. After initial compaction, further smooth and compact concrete by means of hand-operated longitudinal rollers. Use rollers that are not less than 6 feet long and 8 inches in diameter and stiffened to prevent flexing and warping. Operate the paving equipment to produce a thoroughly compacted concrete layer throughout, requiring no hand finishing, other than the use of jointing

tools, except in very infrequent instances.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Provide hand finishing equipment for use at all times.

A. Fixed Form Finishing

Strike off and screed concrete to the required slope and cross-section. When using a static roller for consolidation, stiffen the roller to prevent flexing and warping. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

1. Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 0.25 in. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

B. Edging

Immediately after consolidation and jointing, carefully finish slab edges, including edges at formed joints, with an edge having a radius of not less than 0.25 inch. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled.

C. Jointing

Construct joints at the locations, depths, and width dimensions indicated on the project drawings or the approved shop drawings. Saw cut or use the jointing tool to form contraction joints in fresh concrete immediately after the concrete has been compacted to the specified depth and width. Extend expansion joints through the full depth of the pavement. Cut expansion material flush to grade after concrete has fully hardened and provide joint filler material as indicated or as approved on the shop drawings.

3.6 Curing

Cure pervious concrete for a minimum of 7 days. Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein.Maintain temperature of air next to concrete above 40 degrees F for the full curing periods.

A. White-Polyethylene Sheet

Begin curing within 20 minutes of concrete discharge unless longer working time is approved. Lay sheets directly on concrete surface and overlap 12 inches. Make sheeting not less than 24 inches wider than concrete surface to be cured, and weight down on the edges, without using soil or debris, and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure sheets are soundly in place. If moisture evaporates, re-saturate concrete and replace polyethylene on pavement (limit re-saturation and re-placing no longer than 10 minutes per sheet).

3.7 FIELD QUALITY CONTROL

A. Sampling

Collect samples of fresh concrete in accordance with ASTM C172/C172M during each working

day as required to perform tests specified herein.

B. Consistency Tests

Conduct concrete density tests on the fresh concrete in accordance with ASTM C1688/C1688M. Take samples for density determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 50 cubic yards (maximum) of concrete to ensure that specification requirements are met.

C. Sample Cores

After a minimum of seven days following each placement, take three cores at random locations. Core hardened concrete panels in accordance with ASTM C42/C42M. Test thickness and density of the cores in accordance with ASTM C1542/C1542M and ASTM C1754/C1754M Drying Method B, respectively. Compute the tolerance for core thickness and density reported as the average of three cores of each test panel. Fill core holes with regular concrete or pre-mixed grout.

D. Field Infiltration Tests

After the curing period is complete, determine the infiltration rate of the pervious concrete in accordance with ASTM C1701/C1701M. Locate field infiltration tests at three random locations for each 10000 square feet of pervious concrete surface area. Determine the location of each test using GPS or other methods suitable to repeat testing during the life of the pavement. Submit the test results For Information Only.

E. Surface Testing

Perform surface testing for surface smoothness and plan grade as indicated below. Reference the measurements in accordance with paving lane identification and stationing, and submit a report within 24 hours after measurement is made. Upon conclusion of surface testing, submit a final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies. Mechanically sweep pavement before testing hardened concrete for compliance tolerances.

1. Surface Smoothness Requirements

Provide the finished surfaces of the pavements with no abrupt change of 1/8 inch or more, and within the tolerances specified in Table 1 when checked with a 12 foot straightedge.

2. Surface Smoothness Testing Method

Test the surface of the pavement with the straightedge to identify all surface irregularities exceeding the tolerances specified above. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines approximately 4.5 m 15 feet apart. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Make the measurement of the gap with a steel spacer bar of rectangular section the same thickness as the allowable gap, and width of four times the nominal maximum aggregate size.

F. Plan Grade Testing and Conformance

Check each pavement category for conformance with plan grade requirements by running lines of levels to determine the elevation at locations on the pavement surface 15 feet on center.

3.8 Pavement Protection

Protect the pavement against all damage prior to final acceptance of the work. Do not stockpile aggregates, landscaping materials, or other construction materials on pervious concrete pavements. Keep all new and existing pervious pavement carrying construction traffic or equipment completely clean and clean up spillage of concrete or other materials immediately upon occurrence. Remove dust, leaves and debris with a leaf blower or dry vacuum.

3.9 Open To Traffic

Do not open the pavement to vehicular traffic until the concrete has cured at least 7 uninterrupted days during which the ambient temperature has exceeded 55 deg F or until the pavement is accepted.

END OF SECTION 32 13 43

SECTION 32 13 73

CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Joint-sealant backer materials.
4. Primers.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data:
1. Concrete pavement joint sealants.
2. Joint-sealant backer materials.

B. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type of joint sealant.

C. Samples for Verification: Actual sample of finished products for each kind and color of joint sealant required.
1. Size: Joint sealants in 1/2-inch-wide joints formed between two 6-inch-long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Paving-Joint-Sealant Schedule: Include the following information:
1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Statements: For Installer.

1.5 QUALITY ASSURANCE

A. Qualifications:
1. Installers: Entity that employs installers and supervisors who are trained and approved by manufacturer.

1.6 PRECONSTRUCTION TESTING

A. Preconstruction Testing: Performed by a qualified testing agency.

1.7 FIELD CONDITIONS

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

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

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

2.2 JOINT SEALANTS, GENERAL

A. Compatibility: Provide joint sealants, backer materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.3 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D5893/D5893M, Type NS.

B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D5893/D5893M, Type SL.

C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade NS, Class 25, for Use T.

D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type S, Grade P, Class 25, for Use T.

E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade P, Class 25, for Use T.

2.4 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant, Type I, II, or III: ASTM D6690.

2.5 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.6 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backers to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backer materials.
   2. Do not stretch, twist, puncture, or tear joint-sealant backer materials.
   3. Remove absorbent joint-sealant backer materials that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backer material installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants in accordance with the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

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

END OF SECTION 32 13 73

SECTION 32 17 13

PARKING BUMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Precast concrete wheel stops.

1.3 ACTION SUBMITTALS

A. Product Data:
   1. Precast concrete wheel stops.

B. Sustainable Design Submittals:
   1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.

C. Samples for Initial Selection: For each type of exposed finish requiring color selection.

D. Samples for Verification: For wheel stops, 6 inches long, showing color and cross section; with mounting hardware.

PART 2 - PRODUCTS

2.1 PARKING BUMPERS

A. Precast Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete; 4000-psi minimum compressive strength; Dimensions per plan details. Provide chamfered corners and a minimum of two factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.
   1. Source Limitations: Obtain wheel stops from single source from single manufacturer.
   2. Surface Appearance: Smooth, free of pockets, sand streaks, honeycombs, and other obvious defects. Corners shall be uniform, straight, and sharp.
   3. Surface Sealer: Manufacturer's standard salt-resistant, clear sealer, applied at precasting location.
   4. Mounting Hardware: Iron pins 5/8” diameter x 24 inch long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation in accordance with manufacturer's written instructions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wheel stops in accordance with manufacturer's written instructions unless otherwise indicated.

B. Install wheel stops in bed of adhesive before anchoring to substrate.

C. Securely anchor wheel stops to substrate with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer. Recess head of hardware beneath top of wheel stop.

END OF SECTION 32 17 13

SECTION 32 17 23

PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Painted markings applied to asphalt paving.
   2. Painted markings applied to concrete surfaces.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to marking asphalt paving or concrete surfaces including, but not limited to, the following:
      a. Asphalt-paving or concrete-surface aging period before application of pavement markings.
      b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

1.4 ACTION SUBMITTALS

A. Product Data: Include technical data and tested physical and performance properties.
   1. Pavement-marking paint, alkyd.
   2. Pavement-marking paint, solvent-borne.
   3. Pavement-marking paint, acrylic.
   4. Pavement-marking paint, latex.
   5. Glass beads.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of Section 620 of the MoDOT Missouri Standard Specifications for Highway Construction for pavement-marking work.
   1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain pavement-marking paints from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the 2012 Americans with Disabilities Act.

2.3 PAVEMENT-MARKING PAINT

A. All pavement marking paint shall be in accordance with Section 620 of the MoDOT Missouri Standard Specifications for Highway Construction
   1. Color: As indicated.

B. Glass Beads: AASHTO M 247, Type 1 or FS TT-B-1325D, Type 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement-marking substrate is dry and in suitable condition to begin pavement marking in accordance with manufacturer's written instructions.

B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

A. Pavement marking locations show on the plans are approximate. Proposed crosswalks and stop bars shall be adjusted, if necessary, to match field conditions. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow asphalt paving or concrete surfaces to age for a minimum of 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Pavement markings shall be applied according to Section 620 of the MoDOT Missouri Standard Specifications for Highway Construction.

3.3 PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 32 17 23

SECTION 32 17 26

TACTILE WARNING SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cast-in-place detectable warning tiles.

B. Related Requirements:

1. Section 32 13 13 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.

C. Samples for Initial Selection: For each type of exposed finish requiring color selection.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

1.5 REINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.6 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Mortar and Grout:

1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks, and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F and higher.

    a. When ambient temperature exceeds 100 deg F, or when wind velocity exceeds 8 mph and ambient temperature exceeds 90 deg F, set unit pavers within 1 minute of spreading setting-bed mortar.

1.7 WARRANTY

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

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

    a. Deterioration of finishes beyond normal weathering and wear.

    b. Separation or delamination of materials and components.

2. Warranty Period: One years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in the Americans with Disabilities Act for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

B. Regional Materials: Manufacture products within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

C. Source Limitations: Obtain each type of tactile warning surfacing, joint material, setting material, anchor, and fastener from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.

1. Material: Cast-fiber-reinforced polymer concrete tile.

2. Color: Red brick or as selected by Architect from manufacturer's full line.

3. Shapes and Sizes:

    a. Rectangular panel, 12 by 12 inches.

b. Radius panel, nominal 24 inches deep by[**6-foot**] outside radius.

4. Dome Spacing and Configuration: 1.67-inch spacing, in square pattern or 2.35 inch spacing in diamond pattern

5. Mounting:

a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.

b. Detectable warning tile set into formed recess in concrete and adhered with adhesive.

c. Replaceable detectable warning tile wet-set into freshly poured concrete and surface-fastened to permanently embedded anchors.

2.3 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:

1. Furnish Type 304 stainless-steel fasteners for exterior use.

2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.

B. Adhesive: As recommended by manufacturer for adhering tactile warning surfacing unit to pavement.

C. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 32 13 13 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.

2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.

3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 inch from flush.

4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.

5. Clean tiles using methods recommended in writing by manufacturer.

B. Removable Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 32 13 13 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of removable tile.

2. Set each detectable warning tile accurately and firmly in place with embedding anchors and fasteners attached, and firmly seat tile back in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.

3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 inch from flush.

4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.

5. Clean tiles using methods recommended in writing by manufacturer.

3.4 CLEANING AND PROTECTION

A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 32 17 26

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Chain-link fences.
2. Swing gates.
3. Horizontal-slide gates.
4. Enclosure fence and roof.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete equipment bases/pads for gate operators and controls and post footings.
2. Section 28 15 00 "Access Control Hardware Devices" for gate controls.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Inspect and discuss electrical roughing-in, equipment bases, and other preparatory work specified elsewhere.
2. Review sequence of operation for each type of gate operator.
3. Review coordination of interlocked equipment specified in this Section and elsewhere.
4. Review required testing, inspecting, and certifying procedures.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Fence and gate posts, rails, and fittings.

b. Chain-link fabric, reinforcements, and attachments.

c. Accessories: Barbed wire.

d. Gates and hardware.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.

2. Include accessories, hardware, gate operation, and operational clearances.

C. Samples for Initial Selection: For each type of factory-applied finish.

D. Samples for Verification: For each type of component with factory-applied finish, prepared on Samples of size indicated below:

1. Polymer-Coated Components: In 6-inch lengths for components and on full-sized units for accessories.

E. Delegated-Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer and factory-authorized service representative.

B. Product Certificates: For each type of chain-link fence, and gate.

C. Product Test Reports: For framework strength according to ASTM F1043, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Emergency Access Requirements: According to requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.

C. Mockups: Build mockups to set quality standards for fabrication and installation.

1. Build mockup for typical chain-link fence, including accessories.

a. Size: 10-foot length of fence.

1.7 FIELD CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.8 WARRANTY

A. Special Warranty: Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

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

a. Failure to comply with performance requirements.

b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

c. Faulty operation of gate operators.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design chain-link fence and gate frameworks.

B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7.

1. Design Wind Load: As indicated on Drawings.

a. Minimum Post Size: Determine according to ASTM F1043 for post spacing not to exceed 10 feet for Material Group IA, ASTM F1043, Schedule 40 steel pipe.

b. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified.

C. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.

2.2 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: As indicated on Drawings.

2. Steel Wire for Fabric: Wire diameter of 0.192 inch.

a. Mesh Size: 2 inches.

b. Aluminum-Coated Fabric: ASTM A491, Type I, 0.40 oz./sq. ft..

c. Zinc-Coated Fabric: ASTM A392, Type II, Class 2, 2.0 oz./sq. ft. with zinc coating applied after weaving.

d. Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F1345, Type III, Class 2, 1.0 oz./sq. ft..

e. Polymer-Coated Fabric: ASTM F668, Class 2b over aluminum or zinc-coated steel wire.

1) Color: As selected by Architect from manufacturer's full range, according to ASTM F934.

3. Selvage: Twisted and barbed top and bottom.

2.3 FENCE FRAMEWORK

A. Posts and Rails **UFC 4-022-03 UFC-700**: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 or ASTM F1083 based on the following:

1. Fence Height: As indicated on Drawings.

2. Horizontal Framework Members: top and bottom rails according to ASTM F1043.

a. Top Rail: 1.66 inches in diameter.

3. Metallic Coating for Steel Framework:

a. Type A: Not less than minimum 2.0-oz./sq. ft. average zinc coating according to ASTM A123/A123M or 4.0-oz./sq. ft. zinc coating according to ASTM A653/A653M.

b. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.

c. External, Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil-thick, zinc-pigmented coating.

d. Type C: Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. coating.

e. Coatings: Any coating above.

4. Polymer coating over metallic coating.

a. Color: Match chain-link fabric, according to ASTM F934.

2.4 SWING GATES

A. General: ASTM F900 for gate posts and double swing gate types.

1. Gate Leaf Width: As indicated.

2. Framework Member Sizes and Strength: Based on gate fabric height as indicated.

B. Pipe and Tubing:

1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework <Insert finish>.

2. Aluminum: ASTM B429/B429M; manufacturer's standard finish.

3. Gate Posts: Round tubular steel.

4. Gate Frames and Bracing: Round tubular steel.

C. Frame Corner Construction: assembled with corner fittings.

D. Extended Gate Posts and Frame Members: Fabricate gate posts and frame end members to extend as indicated above top of chain-link fabric at both ends of gate frame to attach barbed wire assemblies.

E. Hardware:

1. Hinges: 360-degree inward and outward swing.

2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.

3. Lock: Manufacturer's standard internal device.

4. Padlock and Chain: Provide padlock conforming to ASTM F883, with chain.

5. Closer: Manufacturer's standard.

2.5 HORIZONTAL-SLIDE GATES

A. General: ASTM F1184 for gate posts and double sliding gate types. Provide automated vehicular gates according to ASTM F2200.

1. Classification: Type II Cantilever Slide, Class 2 with internal roller assemblies.

a. Gate Frame Width and Height: As indicated.

B. Pipe and Tubing:

1. Zinc-Coated Steel: Protective coating and finish to match fence framework.

2. Gate Posts: ASTM F1184. Provide round tubular steel posts.

3. Gate Frames and Bracing: Round tubular steel.

C. Frame Corner Construction: assembled with corner fittings.

D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame as indicated as required to attach barbed wire assemblies.

1. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.

2. Padlock and Chain: Provide padlock conforming to ASTM F883, with chain.

2.6 ENCLOSURE FENCE AND ROOF

A. General: Provide a chain link fence roof for enclsures as indicated on the plans.

B. Fabric:Provide fabric in one-piece heights measured between outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric width: As indicated on Drawings.

2. Steel Wire for Fabric: Wire diameter of 0.192 inch.

a. Mesh Size: 2 inches.

b. Aluminum-Coated Fabric: ASTM A491, Type I, 0.40 oz./sq. ft..

c. Zinc-Coated Fabric: ASTM A392, Type II, Class 2, 2.0 oz./sq. ft. with zinc coating applied after weaving.

d. Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F1345, Type III, Class 2, 1.0 oz./sq. ft..

e. Polymer-Coated Fabric: ASTM F668, Class 2b over aluminum or zinc-coated steel wire.

1) Color: As selected by Architect from manufacturer's full range, according to ASTM F934.

3. Selvage: Twisted and barbed top and bottom.

C. Posts and Rails as indicated on the drawings: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 or ASTM F1083 based on the following:

1. Fence Dimensions: As indicated on Drawings.

2. Horizontal Framework Members: top and bottom rails according to ASTM F1043.

a. Top Rail: 1.66 inches in diameter.

3. Metallic Coating for Steel Framework:

a. Type A: Not less than minimum 2.0-oz./sq. ft. average zinc coating according to ASTM A123/A123M or 4.0-oz./sq. ft. zinc coating according to ASTM A653/A653M.

b. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.

c. External, Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil-thick, zinc-pigmented coating.

d. Type C: Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. coating.

e. Coatings: Any coating above.

4. Polymer coating over metallic coating.

a. Color: Match chain-link fabric, according to ASTM F934.

2.7 FITTINGS

A. Provide fittings according to ASTM F626.

B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive tension wire or top rail.

C. Rail and Brace Ends: For each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:

1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches long.

2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails to posts.

E. Tension and Brace Bands: Pressed steel.

F. Tension Bars: Steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.

G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

H. Barbed Wire Arms: Pressed steel or cast iron, with clips, slots, or other means for attaching strands of barbed wire, integral with post cap, for each post unless otherwise indicated, and as follows:

1. Provide line posts with arms that accommodate top rail or tension wire.

2. Provide corner arms at fence corner posts unless extended posts are indicated.

3. Single-Arm Type: Type I, slanted arm.

I. Tie Wires, Clips, and Fasteners: According to ASTM F626.

1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:

a. Hot-Dip Galvanized Steel: 0.148-inch- diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.

J. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz./sq. ft. of zinc.

a. Polymer coating over metallic coating.

2. Aluminum: Mill finish.

2.8 BARBED WIRE

A. Steel Barbed Wire: ASTM A121, two-strand barbed wire, 0.099-inch-diameter line wire with 0.080-inch-diameter, four-point round barbs spaced not more than 5 inches o.c.

1. Aluminum Coating: Type A.

2. Zinc Coating: Type Z, Class 3.

B. Polymer-Coated, Galvanized-Steel Barbed Wire: ASTM F1665, two-strand barbed wire, 0.080-inch-diameter line wire with 0.080-inch-diameter, four-point, round galvanized-steel barbs spaced not more than 5 inches o.c.:

1. Polymer Coating: [**Class 2b**] over zinc-coated steel wire.

a. Color: As selected by Architect from manufacturer's full range according to ASTM F934.

2.9 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

2.10 GROUNDING MATERIALS

A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.

2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

1. Install fencing on established boundary lines inside property line.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.

2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 10 feet o.c. maximum.

F. Post Bracing and Intermediate Rails: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric 72 inches or higher, on fences with top rail, and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

2. Extended along top of barbed wire arms and top of fence fabric to support barbed tape.

3. As indicated on Drawings.

G. Top Rail: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

H. Intermediate and Bottom Rails: Secure to posts with fittings.

I. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 2-inch bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 inches o.c.

K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric according to ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 24 inches o.c.

L. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

M. Barbed Wire: Install barbed wire uniformly spaced as indicated on Drawings. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

3.5 GROUNDING AND BONDING

A. Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Fence and Gate Grounding:

1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.

2. Install ground rods and connections at maximum intervals of 1500 feet.

3. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.

4. Ground fence on each side of gates and other fence openings.

   a. Bond metal gates to gate posts.

   b. Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of 150 feet on each side of crossing.

D. Fences Enclosing Electrical Power Distribution Equipment: Ground according to IEEE C2 unless otherwise indicated.

E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.

2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.

F. Connections:

1. Make connections with clean, bare metal at points of contact.

2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.

4. Make above-grade ground connections with mechanical fasteners.

5. Make below-grade ground connections with exothermic welds.

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

G. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor according to NFPA 780.

H. Comply with requirements in Section 26 41 13 "Lightning Protection for Structures."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests.

B. Grounding Tests: Comply with requirements in Section 26 41 13 "Lightning Protection for Structures."

C. Prepare test reports.

3.7 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 32 31 13

SECTION 32 32 20

MECHANICALLY STABILIZED EARTH WALL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

B. Mechanically Stabilized Earth Wall Systems
1. The mechanically stabilized earth wall system shall consist of furnishing and constructing a non-structural leveling pad, select backfill, drainage system, precast concrete facing panels, and soil reinforcement elements mechanically connected to each facing panel. Soil reinforcement shall have sufficient length, strength, and frictional resistance as required by the design.
2. Delegated design of mechanically stabilized earth wall system including internal and global stability shall be included in this work.

C. Related Requirements:
1. Section 31 20 00 "Earth Moving" for excavation for mechanically stabilized earth walls, base material, soil fill, fill placement and compaction, and field in-place density testing.
2. Section 720 of the Missouri Department of Transportation's (MoDOT) "Missouri Standard Specifications for Highway Construction".
   a. Delete Method of Measurement and Basis of Payment. This work shall be lump sum.
   b. Delete the last sentence of Article 720.3.4 and replace with the following sentence:
      1) Overall global stability shall be the responsibility of the contractor.

D. General Requirements:
1. The contractor shall be responsible for the internal and external stability of the including compound stability.
2. The Contractor shall be responsible for overall global stability.
3. See section 7.7 and 7.8 of the Geotechnical Report dated July 22, 2022 for geotechnical parameters including a preliminary analysis of global stability.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Show sizes, profiles, coursing, and locations of mechanically stabilized earth wall units; including backfill and leveling base materials.
2. Show types, sizes, locations of soil reinforcing materials.
3. Drainage system.
4. Signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and textures for mechanically stabilized earth wall units.

D. Samples for Verification: Actual sample of finished products for each type of exposed finish of mechanically stabilized earth wall units.
1. Size: Manufacturers' standard size.

E. Delegated Design Submittals: Complete design plans, details and computations for each individual wall structure as specified in Section 720 of the Missouri Department of Transportation's (MoDOT) "Missouri Standard Specifications for Highway Construction. Documents shall be sealed by a qualified professional engineer licensed in Missouri responsible for their preparation.

F. Sustainable Design Submittals:
1. Environmental Product Declaration (EPD): For each product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:
1. Mechanically Stabilized Earth Wall Systems Prequalification on MoDOT's bridge prequalification list and a letter indicating any deviations from the prequalified product as specified in Article 720.3.1 MoDOT "Missouri Standard Specifications for Highway Construction".
2. For testing agency.

B. Product Certificates: For each type of panel unit or facing unit, and soil reinforcement from manufacturer.

1. Include test data for shear strength between wall units in accordance with ASTM D6916.

2. Include test data for connection strength between wall units and soil reinforcement in accordance with ASTM D6638.

C. Test and Evaluation Reports:
1. Product Test Reports: For each type of panel unit or facing unit, and soil reinforcement, for tests performed by manufacturer and witnessed by a qualified testing agency.
   a. Include test data for shear strength between wall units in accordance with ASTM D6916.
   b. Include test data for connection strength between wall units and soil reinforcement in accordance with ASTM D6638.
2. Research Reports: For Mechanically Stabilized Earth Wall Systems, from an agency acceptable to authorities having jurisdiction showing compliance with building code requirements.
3. Preconstruction Test Reports: For wall panel units and soil reinforcement.

D. Source Quality-Control Submittals:
1. Source quality-control reports.

E. Field Quality-Control Submittals:
1. Field quality-control reports.

F. Qualification Statements: For testing agency.

G. Delegated design engineer qualifications.

1.5 QUALITY ASSURANCE

A. Qualifications:
1. Mechanically Stabilized Earth Wall Systems: Only systems shown on the prequalification on MoDOT's bridge prequalification list are allowed as indicated in Article 720.3.1 MoDOT "Missouri Standard Specifications for Highway Construction".
2. Installers: Entity that employs experienced installers. Provide documentation to demonstrate experience and successful construction of mechanically stabilized earth wall system installation of similar size and scope in Missouri or Metro St. Louis area.
3. Delegated Design Engineer: A professional engineer who is legally qualified to practice in Missouri where Project is located and who is experienced in providing engineering services of the type indicated.
4. Testing Agency: Qualified in accordance with ASTM E329 for testing indicated.

1.6 MOCKUPS

A. Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects.
1. Build mockup of mechanically stabilized earth wall approximately 72 inches long by not less than 36 inches high above finished grade at front of wall.
   a. Include typical soil reinforcement.
   b. Include typical base and cap or finished top construction.
   c. Include backfill to typical finished grades at both sides of wall.
   d. Include typical end construction at one end of mockup.
   e. Include 36-inch return at one end of mockup, with typical corner construction.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
1. Test soil reinforcement and backfill materials for pullout resistance in accordance with ASTM D6706.
2. Test soil reinforcement and backfill materials for coefficient of friction in accordance with ASTM D5321/D5321M.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.

B. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F or below 32 deg F, and other conditions that might damage them. Verify identification of geosynthetics before use, and examine them for defects as material is placed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: In accordance with Section 720 of the Missouri Department of Transportation's (MoDOT) "Missouri Standard Specifications for Highway Construction.

2.2 MECHANICALLY STABILIZED EARTH WALL SYSTEM MATERIALS

A. Materials shall be in accordance with Section 720 of the Missouri Department of Transportation's (MoDOT) "Missouri Standard Specifications for Highway Construction.

B. Regional Materials: Manufacture units within 100 miles of Project site from aggregates that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

C. Color and Texture: All visible materials shall be as selected by Architect from manufacturer's full range.

2.3 INSTALLATION MATERIALS

A. Installation materials shall be in accordance with Section 720 of the MoDOT "Missouri Standard Specifications for Highway Construction".

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF MECHANICALLY STABILIZED EARTH WALL SYSTEM

A. Installation shall be in accordance with Section 720 of the Missouri Department of Transportation's (MoDOT) "Missouri Standard Specifications for Highway Construction.

3.3 FILL PLACEMENT

A. General: Comply with requirements in Section 31 20 00 "Earth Moving," with manufacturer's written instructions, and Section 720 of the Missouri Department of Transportation's (MoDOT) "Missouri Standard Specifications for Highway Construction. If there is a conflict between this specification and the MoDOT specification, the most stringent requirement shall apply.

B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.

C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.

1. Use only hand-operated compaction equipment within 48 inches of wall or one-half of height above bottom of wall, whichever is greater.
2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
   a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight in accordance with ASTM D698.
   b. In areas where fill height exceeds 15 feet compact reinforced-soil fill that will be more than 15 feet below finished grade to not less than 98 percent maximum dry unit weight in accordance with ASTM D698.
   c. In areas where fill height exceeds 30 feet compact reinforced-soil fill that will be more than 30 feet below finished grade to not less than 100 percent maximum dry unit weight in accordance with ASTM D698.
3. Compact nonreinforced-soil fill to comply with Section 31 20 00 "Earth Moving."

D. Place drainage geotextile against back of wall, and place layer of drainage fill at least 12 inches wide behind drainage geotextile to within 12 inches of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.

E. Place a layer of drainage fill at least 12 inches wide behind wall to within 12 inches of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.

F. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated, sloped not less than 0.5 percent to drain.

G. Place impervious fill over top edge of drainage fill layer.

H. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at wall base away from wall. Provide uniform slopes that prevent ponding.

I. Place soil reinforcement in horizontal joints of mechanically stabilized earth wall where indicated and in accordance with soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches into mechanically stabilized earth wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
   1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
   2. Place geosynthetics with seams, if any, oriented perpendicularly to wall face panels.
   3. Do not dump fill material directly from trucks onto geosynthetics.
   4. Place at least 6 inches of fill over reinforcement before compacting with tracked vehicles or 4 inches before compacting with rubber-tired vehicles.
   5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

3.4 CONSTRUCTION TOLERANCES

A. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet, 3 inches maximum.

B. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet.

C. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet.

D. Maximum Gap between Units: 1/8 inch.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections during construction.

B. Comply with requirements in Section 31 20 00 "Earth Moving" for field quality control.

C. Tests and Inspections:
1. In each compacted backfill layer, perform at least one field in-place compaction test for each 24 inches of fill depth and each 50 feet or less of mechanically stabilized earth wall length.
2. mechanically stabilized earth system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Remove and replace mechanically stabilized earth wall construction of the following descriptions:
1. Broken, chipped, stained, or otherwise damaged facing panels. Panels may be repaired if Architect approves methods and results.
2. Retaining walls that do not match approved Samples and mockups.
3. Retaining walls that do not comply with other requirements indicated.

B. Replace panels so mechanically stabilized earth wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 32 32 20

SECTION 32 32 23

SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Segmental block retaining walls.

B. Related Requirements:
1. Section 31 20 00 "Earth Moving" for excavation for segmental retaining walls, base material, soil fill, fill placement and compaction, and field in-place density testing.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show sizes, profiles, coursing, and locations of retaining wall units; including backfill and leveling base materials.

2. Show types, sizes, locations of soil reinforcing materials.

3. Drainage system.

4. Signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and textures for segmental retaining wall units.

D. Samples for Verification: Actual sample of finished products for each type of exposed finish of segmental retaining wall units.
1. Size: Manufacturers' standard size.

E. Delegated Design Submittals:For segmental block retaining walls, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1.

F. Sustainable Design Submittals:
1. Environmental Product Declaration (EPD): For each product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Product Certificates: For each type of segmental retaining wall unit and soil reinforcement from manufacturer.

1. Include test data for shear strength between segmental retaining wall units in accordance with ASTM D6916.

2. Include test data for connection strength between segmental retaining wall units and soil reinforcement in accordance with ASTM D6638.

C. Test and Evaluation Reports:
1. Product Test Reports: For each type of segmental retaining wall unit and soil reinforcement, for tests performed by manufacturer and witnessed by a qualified testing agency.
   a. Include test data for shear strength between segmental retaining wall units in accordance with ASTM D6916.
   b. Include test data for connection strength between segmental retaining wall units and soil reinforcement in accordance with ASTM D6638.
2. Research Reports: For segmental retaining wall system, from an agency acceptable to authorities having jurisdiction showing compliance with building code requirements.
3. Preconstruction Test Reports: For segmental retaining wall units and soil reinforcement.

D. Source Quality-Control Submittals:
1. Source quality-control reports.

E. Field Quality-Control Submittals:
1. Field quality-control reports.

F. Qualification Statements: For testing agency.

G. Delegated design engineer qualifications.

1.5 QUALITY ASSURANCE

A. Qualifications:
1. Installers: Entity that employs installers certified under the National Concrete Masonry Association (NCMA) Certified Segmental Retaining Wall Installer program at the Advanced Commercial certification level.
2. Delegated Design Engineer: A professional engineer who is legally qualified to practice in Missouri where Project is located and who is experienced in providing engineering services of the type indicated.
3. Testing Agency: Qualified in accordance with ASTM E329 for testing indicated.

1.6 MOCKUPS

A. Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects.
1. Build mockup of segmental retaining wall approximately 72 inches long by not less than 36 inches high above finished grade at front of wall.
   a. Include typical soil reinforcement.
   b. Include typical base and cap or finished top construction.
   c. Include backfill to typical finished grades at both sides of wall.
   d. Include typical end construction at one end of mockup.
   e. Include 36-inch return at one end of mockup, with typical corner construction.

2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
   1. Test soil reinforcement and backfill materials for pullout resistance in accordance with ASTM D6706.
   2. Test soil reinforcement and backfill materials for coefficient of friction in accordance with ASTM D5321/D5321M.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.

B. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F or below 32 deg F, and other conditions that might damage them. Verify identification of geosynthetics before use, and examine them for defects as material is placed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design segmental retaining walls.

B. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.

C. Structural Performance: Engineering design shall be based on the following loads and be in accordance with NCMA's "Design Manual for Segmental Retaining Walls."
   1. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
   2. Superimposed loads (surcharge) indicated on Drawings.
   3. Horizontal Peak Ground Acceleration (A) for Project: .
   4. Geotechnical parameters defined in the Geotechnical Report.

2.2 SEGMENTAL RETAINING WALL UNITS

A. Concrete Units: ASTM C1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus 1/16 inch from specified dimension.
   1. Provide units that comply with requirements in ASTM C1372 for freeze-thaw durability as determined by testing.
   2. Provide units that interlock with courses above and below by means of integral lugs, lips, or tongues and grooves pins, clips, or splines.

B. Regional Materials: Manufacture units within 100 miles of Project site from aggregates that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

C. Color: As selected by Architect from manufacturer's full range.

D. Shape and Texture:
1. Provide units of any basic shape and dimensions that produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with machine-split textured.

E. Batter: Provide units that offset from course below to provide 1:8 batter.

F. Cap Units: Provide cap units of same shape as other units with smooth, as-cast top surfaces without holes or lugs.

G. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching face.

2.3 INSTALLATION MATERIALS

A. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.

B. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.

C. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.

D. Leveling Base: Comply with requirements in Section 31 20 00 "Earth Moving" for drainage course.

E. Drainage Fill: Comply with requirements in Section 31 20 00 "Earth Moving" for drainage course.

F. Reinforced Soil Fill:
1. Comply with requirements in Section 31 20 00 "Earth Moving" for satisfactory soils.

G. Nonreinforced-Soil Fill: Comply with requirements in Section 31 20 00 "Earth Moving" for satisfactory soils.

H. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

I. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation of greater than 50 percent.
1. Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D4751.
2. Minimum Grab Tensile Strength: 110 lb; ASTM D4632/D4632M.
3. Minimum Weight: 4 oz./sq. yd..

J. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement and as follows:
1. Product Type: Molded geogrid made from high-density polyethylene

2.4 SOURCE QUALITY CONTROL

A. Factory test and inspect each roll of soil reinforcement for minimum average roll values for geosynthetic index property tests, including the following:
   1. Weight.
   2. Grab or single-rib strength.
   3. Aperture opening.
   4. Rib or yarn size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF RETAINING WALLS

A. General: Place units in accordance with NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
   1. Lay units in running bond.
   2. Form corners and ends by using special units

B. Do not use units with chips, cracks, or other defects that are visible at a distance of 20 feet where such defects are exposed in the completed Work.

C. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
   1. Leveling Course: At Contractor's option, unreinforced lean concrete may be substituted for upper 1 to 2 inches of base Compact and screed concrete to a smooth, level surface.

D. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
   1. Tamp units into leveling base as necessary to bring tops of units into a level plane.

E. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
   1. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
   2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
   3. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
   4. For units with pins, install pins and align units.
   5. For units with clips, install clips and align units.

F. Cap Units: Place cap units and secure with cap adhesive.

3.3 FILL PLACEMENT

A. General: Comply with requirements in Section 31 20 00 "Earth Moving," with NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.

B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.

C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.
   1. Use only hand-operated compaction equipment within 48 inches of wall or one-half of height above bottom of wall, whichever is greater.
   2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
      a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight in accordance with ASTM D698.
      b. In areas where fill height exceeds 15 feet compact reinforced-soil fill that will be more than 15 feet below finished grade to not less than 98 percent maximum dry unit weight in accordance with ASTM D698.
      c. In areas where fill height exceeds 30 feet compact reinforced-soil fill that will be more than 30 feet below finished grade to not less than 100 percent maximum dry unit weight in accordance with ASTM D698.
   3. Compact nonreinforced-soil fill to comply with Section 31 20 00 "Earth Moving."

D. Place drainage geotextile against back of wall, and place layer of drainage fill at least 12 inches wide behind drainage geotextile to within 12 inches of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.

E. Place a layer of drainage fill at least 12 inches wide behind wall to within 12 inches of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.

F. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated, sloped not less than 0.5 percent to drain.

G. Place impervious fill over top edge of drainage fill layer.

H. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at wall base away from wall. Provide uniform slopes that prevent ponding.

I. Place soil reinforcement in horizontal joints of retaining wall where indicated and in accordance with soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
   1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
   2. Place geosynthetics with seams, if any, oriented perpendicularly to segmental retaining walls.
   3. Do not dump fill material directly from trucks onto geosynthetics.
   4. Place at least 6 inches of fill over reinforcement before compacting with tracked vehicles or 4 inches before compacting with rubber-tired vehicles.

5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

3.4 CONSTRUCTION TOLERANCES

A. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet, 3 inches maximum.

B. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet.

C. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet.

D. Maximum Gap between Units: 1/8 inch.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Comply with requirements in Section 31 20 00 "Earth Moving" for field quality control.

C. Tests and Inspections:
1. In each compacted backfill layer, perform at least one field in-place compaction test for each 24 inches of fill depth and each 50 feet or less of segmental retaining wall length.
2. Segmental retaining wall system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Remove and replace segmental retaining wall construction of the following descriptions:
1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Architect approves methods and results.
2. Segmental retaining walls that do not match approved Samples and mockups.
3. Segmental retaining walls that do not comply with other requirements indicated.

B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 32 32 23

SECTION 32 92 00

TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Seeding.
2. Hydroseeding.
3. Erosion-control materials.
4. Grass-paving materials.

B. Related Requirements:

1. Section 32 93 00 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

C. Product Certificates: For fertilizers, from manufacturer.

D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk materials with appropriate certificates.

1.9 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 1 to June 15.

2. Fall Planting: September 15 to November 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:

1. Quality, State Certified: State-certified seed of grass species as listed below for solar exposure.

2. Quality, Non-State Certified: Seed of grass species as listed below for solar exposure, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:

C. Grass-Seed Mix: Proportioned by weight as follows:

1. 33% Annual Ryegrass

2. 20% Spring Oats

3. 20% Perennial Ryegrass

4. 27% Buffalo Grass

2.2 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition:

a. 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition:

a. 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.

b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.3 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

2.4 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.5 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

C. Erosion-Control Mats: Cellular, nonbiodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of 6-inch nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.

2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.

2. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 804 of the Missouri Standard Specifications for Highway Construction.

B. Placing Planting Soil: Blend planting soil in place.

1. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.

1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

2. Do not use wet seed or seed that is moldy or otherwise damaged.

3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 6 to 8 lb/1000 sq. ft..

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with erosion-control mats where indicated on Drawings; install and anchor according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

3.6 HYDROSEEDING

A. Hydroseeding: Mix specified seed, commercial fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.

2. Spray-apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3. Spray-apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre.

3.7 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 95 percent over any 10 sq. ft. and bare spots not exceeding 6 by 6 inches.

2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

3. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.

4. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.8 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.9 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 92 00

SECTION 32 93 00

PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Plants.

2. Tree stabilization.

B. Related Requirements:

1. Section 32 92 00 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.

1.3 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than sizes indicated; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.

2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

B. Samples for Verification: For each of the following:

1. Trees and Shrubs: One Samples of each variety and size delivered to site for review. Maintain approved Samples on-site as a standard for comparison.

2. CompostMulch: 1-pint volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.

3. Mineral Mulch: 2 lb of each mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on-site; provide an accurate indication of color, texture, and makeup of the material.

4. Weed Control Barrier: 12 by 12 inches.

5. Proprietary Root-Ball-Stabilization Device: One unit.

6. Root Barrier: Width of panel by 12 inches.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.

2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

2. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Architect of sources of planting materials seven days in advance of delivery to site.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk materials with appropriate certificates.

C. Deliver bare-root stock plants within 36 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.

2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.

3. Do not remove container-grown stock from containers before time of planting.

4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.11 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 1 to June 15.

2. Fall Planting: September 15 to November 15.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.12 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

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

a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.

b. Structural failures including plantings falling or blowing over.

c. Faulty performance of tree stabilization.

d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods: From date of Substantial Completion.

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.

3. Include the following remedial actions as a minimum:

a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.

b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.

2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: 21-gram tablets.

2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Wood and bark chips.

2. Size Range: 3 inches maximum, 1/2 inch minimum.

3. Color: Natural.

B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1-inch sieve; soluble-salt content of 2 to 5 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.

2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd..

2.5 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

2.6 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.

2. Wood Deadmen: Timbers measuring 8 inches in diameter and 48 inches long, treated with specified wood pressure-preservative treatment.

3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles.

4. Guys and Tie Wires: ASTM A641/A641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.

5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.

6. Guy Cables: Five-strand, 3/16-inch-diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches long, with two 3/8-inch galvanized eyebolts.

7. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

B. Root-Ball Stabilization Materials:

1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated; stakes pointed at one end.

2. Wood Screws: ASME B18.6.1.

2.7 MISCELLANEOUS PRODUCTS

A. Wood Pressure-Preservative Treatment: AWPA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.

B. Root Barrier: Black, molded, modular panels 18 inches high (deep), 85 mils thick, and with vertical root deflecting ribs protruding 3/4 inch out from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.

C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

D. Burlap: Non-synthetic, biodegradable.

E. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.

2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.

3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

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

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 804 of the Missouri Standard Specifications for Highway Construction.

B. Placing Planting Soil: Blend planting soil in place.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.

2. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.

3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.

4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.

5. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.

6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.

7. Maintain supervision of excavations during working hours.

8. Keep excavations covered or otherwise protected overnight.

9. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch-diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.

1. Backfill: Planting soil. For trees, use excavated soil for backfill.

2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.

    a. Quantity: Two for each caliper inch of plant.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 MECHANIZED TREE-SPADE PLANTING

A. Trees maybe planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.

B. Use the same tree spade to excavate the planting hole as will be used to extract and transport the tree.

C. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.

D. Cut exposed roots cleanly during transplanting operations.

E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.

F. Where possible, orient the tree in the same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:

1. Upright Staking and Tying:

    a. Stake trees of 2- through 5-inch caliper. Stake trees of less than 2-inch caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend one-third of trunk height above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.

2. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than 14 feet in height and more than 3 inches in caliper unless otherwise indicated.

1. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.

a. Securely attach guys to stakes 30 inches long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses. Provide turnbuckle for each guy wire and tighten securely.

b. For trees more than 6 inches in caliper, anchor guys to wood deadmen buried at least 36 inches below grade. Provide turnbuckle for each guy wire and tighten securely.

c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.

d. Attach flags to each guy wire, 30 inches above finish grade.

2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of the vertical stakes.

a. Install stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation. Saw stakes off at horizontal stake.

b. Install screws through horizontal hold-down and penetrating at least 1 inch into stakes. Predrill holes if necessary to prevent splitting wood.

c. Install second set of stakes on other side of root trunk for larger trees.

3.9 INSTALLATION OF ROOT BARRIER

A. Install root barrier where trees are planted within 60 inches of paving or other hardscape elements, such as walls, curbs, and walkways, unless otherwise indicated on Drawings.

B. Align root barrier vertically, and run it linearly along and adjacent to the paving or other hardscape elements to be protected from invasive roots.

C. Install root barrier continuously for a distance of 60 inches in each direction from the tree trunk, for a total distance of 10 feet per tree. If trees are spaced closer, use a single continuous piece of root barrier.

1. Position top of root barrier according to manufacturer's written recommendations.

2. Overlap root barrier a minimum of 12 inches at joints.

3. Do not distort or bend root barrier during construction activities.

4. Do not install root barrier surrounding the root ball of tree.

3.10 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees in Turf Areas: Apply organic mulch ring of 2-inch average thickness, with 24-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.

3.11 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.12 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.13 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.

1. Submit details of proposed pruning and repairs.

2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.

3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.

1. Provide new trees of same size as those being replaced for each tree of 6 inches Insert dimension or smaller in caliper size.

2. Species of Replacement Trees: Same species being replaced.

3.14 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

D. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

END OF SECTION 32 93 00

SECTION 33 05 00

COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
1. Piping joining materials.
2. Transition fittings.
3. Dielectric fittings.
4. Sleeves.
5. Identification devices.
6. Grout.
7. Flowable fill.
8. Piped utility demolition.
9. Piping system common requirements.
10. Equipment installation common requirements.
11. Painting.
12. Concrete bases.
13. Metal supports and anchorages.

1.3 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

B. Concealed 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.

C. ABS: Acrylonitrile-butadiene-styrene plastic.

D. CPVC: Chlorinated polyvinyl chloride plastic.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
1. Dielectric fittings.
2. Identification devices.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Steel Piping 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. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

A. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 PIPING 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 otherwise 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.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

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

G. Solvent Cements for Joining Plastic Piping:
1. ABS Piping: ASTM D2235.
2. CPVC Piping: ASTM F493.
3. PVC Piping: ASTM D2564. Include primer according to ASTM F656.
4. PVC to ABS Piping Transition: ASTM D3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 TRANSITION FITTINGS

A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings NPS 1-1/2 and Smaller:
1. Underground Piping: Manufactured piping coupling or specified piping system fitting.
2. Aboveground Piping: Specified piping system fitting.
3. AWWA Transition Couplings NPS 2 and Larger:
4. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Plastic-to-Metal Transition Fittings:
1. Description: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint or threaded end.

D. Plastic-to-Metal Transition Unions:
1. Description: MSS SP-107, CPVC and PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:
1. Description: ASTM C1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.3 DIELECTRIC FITTINGS

A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Description: Factory fabricated, union, NPS 2 and smaller.
a. Pressure Rating: 150 psig minimum at 180 deg F.
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:
1. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 and larger.
a. Pressure Rating: 150 psig minimum.
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
1. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 and larger.
a. Pressure Rating: 150 psig minimum.
b. Gasket: Neoprene or phenolic.
c. Bolt Sleeves: Phenolic or polyethylene.
d. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:
1. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 and smaller.
a. Pressure Rating: 300 psig at 225 deg F.
b. End Connections: Threaded.

F. Dielectric Nipples:
1. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.
a. Pressure Rating: 300 psig at 225 deg F.
b. End Connections: Threaded or grooved.

2.4 SLEEVES

A. Mechanical sleeve seals for pipe penetrations are specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

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

C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.5 IDENTIFICATION DEVICES

A. General: Products specified are for applications referenced in other utilities Sections. If more than single type is specified for listed applications, selection is Installer's option.

B. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: Accessible and visible.

C. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is 1-1/4 inches for ducts, and 3/4 inch for access door signs and similar operational instructions.
1. Material: Brass.
2. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.

D. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

E. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.

F. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers, extending 360 degrees around pipe at each location.

G. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.

H. Lettering: Manufacturer's standard preprinted captions as selected by Architect.

I. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

J. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils thick.
1. Width: 1-1/2 inches on pipes with OD, including insulation, less than 6 inches; 2-1/2 inches for larger pipes.
2. Color: Comply with ASME A13.1, unless otherwise indicated.

K. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Include 5/32-inch hole for fastener.
1. Material: Valve manufacturer's standard solid plastic.
2. Size: 1-1/2 inches in diameter, unless otherwise indicated.

L. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

M. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
2. Thickness: 1/16 inch, for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
3. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.

N. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:
   1. Green: Cooling equipment and components.
   2. Yellow: Heating equipment and components.
   3. Brown: Energy reclamation equipment and components.
   4. Blue: Equipment and components that do not meet criteria above.
   5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
   6. Terminology: Match schedules as closely as possible. Include the following:
      a. Name and plan number.
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
   7. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

O. Plasticized Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with mat finish suitable for writing.
   1. Size: 3-1/4 by 5-5/8 inches.
   2. Fasteners: Brass grommets and wire.
   3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.

P. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in piped utility identification with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of piped utility systems and equipment.
   1. Multiple Systems: Identify individual system number and service if multiple systems of same name are indicated.

2.6 GROUT

A. Description: ASTM C1107, 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.

2.7 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix.
   1. Cement: ASTM C150, Type I, portland.
   2. Density: 115- to 145-lb/cu. ft..
   3. Aggregates: ASTM C33, natural sand, fine and crushed gravel or stone, coarse.
   4. Aggregates: ASTM C33, natural sand, fine.
   5. Admixture: ASTM C618, fly-ash mineral.
   6. Water: Comply with ASTM C94/C94M.
   7. Strength: 100 to 200 psig at 28 days.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

A. Refer to Section 02 41 19 "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.
   3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 DIELECTRIC FITTING APPLICATIONS

A. Dry Piping Systems: Connect piping of dissimilar metals with the following:
   1. NPS 2 and Smaller: Dielectric unions.
   2. NPS 2-1/2 to NPS 12: Dielectric flanges or dielectric flange kits.

B. Wet Piping Systems: Connect piping of dissimilar metals with the following:
   1. NPS 2 and Smaller: Dielectric couplings or dielectric nipples.
   2. NPS 2-1/2 to NPS 4: Dielectric nipples.
   3. NPS 2-1/2 to NPS 8: Dielectric nipples or dielectric flange kits.
   4. NPS 10 and NPS 12: Dielectric flange kits.

3.3 PIPING INSTALLATION

A. Install piping according to the following requirements and utilities 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 the Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Permanent sleeves are not required for holes formed by removable PE sleeves.

J. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas 2 inches above finished floor level.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

K. Verify final equipment locations for roughing-in.

L. Refer to equipment specifications in other Sections for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and utilities 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. 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.

E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. Soldered Joints: Apply ASTM B813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.

I. 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.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendixes.
3. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
5. PVC Nonpressure Piping: Join according to ASTM D2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.
1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.5 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. Install dielectric fittings at connections of dissimilar metal pipes.

3.6 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.

C. Install equipment to allow right of way to piping systems installed at required slope.

3.7 PAINTING

A. Painting of piped utility systems, equipment, and components is specified in Section 09 91 13 "Exterior Painting," Section 09 91 23 "Interior Painting," and Section 09 96 00 "High-Performance Coatings."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
   1. Stenciled Markers: According to ASME A13.1.
   2. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
   3. Locate pipe markers on exposed piping according to the following:
      a. Near each valve and control device.
      b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
      c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
      d. At manholes and similar access points that permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.
   1. Lettering Size: Minimum 1/4 inch high for name of unit if viewing distance is less than 24 inches, 1/2 inch high for distances up to 72 inches, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
   2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.9 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 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 Section 03 30 00 "Cast-in-Place Concrete."

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05 50 00 "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.11 GROUTING

A. Mix and install grout for 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.

END OF SECTION 33 05 00

SECTION 33 10 00

WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes water-distribution piping and related components outside the building for water service.

1.2 RELATED WORK

A. Section 31 20 00 - "Earth Moving" for excavation, trenching, and backfilling utilities.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with requirements of the Missouri American Water Company and St. Louis County. Include tapping of water mains, backflow prevention, materials, installation, testing, and disinfection.

B. Contractor is responsible to construct improvements to the lines, grades, and elevations as shown on the Plans and Specifications.

C. Comply with the applicable requirements in the current edition of the “Missouri American Water Pipeline Specifications”.

D. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
   1. Ensure that valves are dry and internally protected against rust and corrosion.
   2. Protect valves against damage to threaded ends and flange faces.
   3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
   1. Notify Architect no fewer than two working-days in advance of proposed interruption of service.
   2. Do not proceed with interruption of water-distribution service without Architect's written permission.

1.7 COORDINATION

A. Coordinate connection to water main and water meter at building with utility company.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Water Main: Ductile iron or PVC according to the provisions of the "Missouri American Water Pipeline Specifications" Latest Edition.

B. Water Service:
   1. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
      a. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
      b. Copper, Pressure-Seal Fittings:
         1) Manufacturers: Subject to compliance with City of Edwardsville requirements.
         2) NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

2.2 JOINING MATERIALS

A. Pipe-Flange Gasket, Bolts, and Nuts: Type and material to match adjoining pipe as recommended by the pipe system manufacturer, unless otherwise indicated.

2.3 WATER METERS

A. As applicable, water meters will be furnished by utility company.

2.4 FIRE HYDRANT ASSEMBLIES

A. As indicated on plans and details.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 31 20 00 - "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

E. Underground water-service piping NPS 3/4 to NPS 3 shall be any of the following:
   1. Copper according to the provisions of the “Missouri American Water Pipeline Specifications” Latest Edition.
   2. PVC according to the provisions of the “Missouri American Water Pipeline Specifications” Latest Edition.

F. Underground water-service piping NPS 4 to NPS 8 shall be any of the following:
   1. PVC according to the provisions of the “Missouri American Water Pipeline Specifications” Latest Edition.
   2. Ductile-iron according to the provisions of the “Missouri American Water Pipeline Specifications” Latest Edition.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts.

3.4 PIPING INSTALLATION

A. Water Main: According to the provisions of the “Missouri American Water Pipeline Specifications” latest edition.

B. Water Service: According to the provisions of the “Missouri American Water Pipeline Specifications” latest edition.

C. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

D. Make connections with tapping machine as to not affect normal operations on the main (e.g., make a hot tap) according to the City of Edwardsville’s requirements.

E. Bury piping with depth of cover over top at least 42 inches.

F. As applicable, install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

G. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
   1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

H. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

3.5 JOINT CONSTRUCTION

A. Make pipe joints according to the following:
   1. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
   2. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.

3.6 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Reaction backing (anchorages) and restrained-joint types that may be used include the following:
   1. Cast in place concrete thrust blocks.
   2. Locking mechanical joints.
   3. Set-screw mechanical retainer glands.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.7 CONNECTIONS

A. Connect water-distribution piping to existing water main.

B. Connect water-distribution piping to interior domestic water and fire-suppression piping.

3.8 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic testing according to Section 4 of AWWA specifications, Designation AWWA C 600.

C. Prepare reports of testing activities.

3.9 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 31 20 00 - "Earth Moving."

B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel.

3.10 CLEANING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.

2. Use purging and disinfecting procedure in accordance with the St. Louis County Department of Public Health.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 33 10 00

SECTION 33 30 00

SANITARY UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities, Latest Edition.

1.2 SUMMARY

A. Section Includes:
   1. General Contractor to provide:
      a. Pipe and fittings.
      b. Cleanouts.
      c. Manholes.

B. Related Work:
   1. Section 31 20 00 - “Earth Moving” for utility trench backfill, excavation, trenching and backfilling.

1.3 SUBMITTALS

A. Product Data: For the following:
   1. Pipe and fittings.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

C. Field quality-control reports.

D. Record Drawings: Identifying and accurately showing locations of utilities and other related field conditions

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

B. Handle manholes according to manufacturer's written rigging instructions.

1.5 QUALITY ASSURANCE

A. Comply with the applicable requirements of the most current version of Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.
   1. Measurement and payment provisions included in the Standard Specifications do not apply to this work.

B. Preinstallation Conference: Conduct conference at Project site.

C. Contractor is responsible to remove items to the lines, grades, and elevations as shown on the Plans and Specifications. The Architect will provide the initial survey control, but the Contractor shall perform their own survey and layout work.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect no fewer than two working days in advance of proposed interruption of service.
   2. Contractor shall develop a plan to convey sewage during the interruption.
   3. Contractor shall indicate the planned duration of the interruption.
   4. Do not proceed with interruption of service without Architect's written permission.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The following material is specified in the most current version of the Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.
   1. PVC Pipe and Fittings
   2. Cleanouts
   3. Manholes and Frames
   4. Concrete

PART 3 - EXECUTION

3.1 INSTALLATION

A. The following construction and installation of material is specified in the most current version of the Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.
   1. Earthwork
   2. Piping Sewer Construction
   3. Pipe joint construction
   4. Manhole Installation
   5. Concrete Placement
   6. Cleanout Installation
   7. Connections

3.2 IDENTIFICATION

A. Materials and their installation are specified in Section 31 20 00 - "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
   1. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.3 FIELD QUALITY CONTROL

A. Comply with the applicable sections of the most current version of the Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
   1. Submit separate report for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.

   3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.

   4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
   3. Submit separate report for each test.
   4. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
      a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
      b. Close openings in system and fill with water.
      c. Purge air and refill with water.
      d. Disconnect water supply.
      e. Test and inspect joints for leaks.
   5. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, and the following:
      a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
   6. Manholes: Perform hydraulic test according to ASTM C 1244

D. Leaks and loss in test pressure constitute defects that must be repaired.

E. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

3.4 CLEANING

A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 33 30 00

SECTION 33 41 00

STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities, Latest Edition.

1.2 SUMMARY

A. Section Includes:

1. Storm Sewer Drainpipe
2. Flat Drains
3. Inlets and Manholes
4. Ductile Iron Frame and Grates
5. Hydro Dynamic Separators
6. Underground Detention Chambers

1.3 RELATED WORK

A. Specified elsewhere:

1. Division Section "Earth Moving" for excavation, trenching, and backfilling utilities.
2. Division Section “Site Clearing” for temporary erosion control.

1.4 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Inlets and Manholes. Include plans, elevations, sections, details, frames, covers, and grates.
2. Trench Drain: Include plans, elevations, sections, details, frames, covers, and grates.
3. Hydro Dynamic Separators: Include plans, elevations, sections, details.
4. Underground Detention Chambers Include plans, elevations, sections, details.

C. Product Certificates: For each type of cast-iron frame and grate from manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect manholes, pipe, pipe fittings, and seals from dirt and damage.

C. Handle inlets and manholes according to manufacturer's written rigging instructions.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of service.
2. Contractor shall develop a plan to convey storm drainage during the interruption.
3. Contractor shall indicate the planned duration of the interruption.
4. Do not proceed with interruption of service without Owner's written permission.

1.7 QUALITY ASSURANCE

A. Contractor is responsible to construct improvements to the lines, grades, and elevations as shown on the Plans and Specifications. The Engineer will provide the initial survey control, but the Contractor shall perform their own survey and layout work.

B. Comply with the applicable requirements of the Missouri Standard Specifications for Highway Construction, latest edition and Metropolitan St. Louis Sewer District (MSD) Standard Construction Specifications for Sewer and Drainage Facilities, latest edition except as noted:

1. Measurement and payment provisions included in the Standard Specifications do not apply to this work.

PART 2 - PRODUCTS

2.1 PE PIPE AND FITTINGS

A. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10 AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Watertight Couplings.

B. Corrugated PE Pipe and Fittings NPS 12 to NPS 60 AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Watertight Couplings:

2.2 PVC PIPE AND FITTINGS

A. PVC Corrugated Sewer Piping according to Article 1040.03 of the Illinois Department of Transportation’s “Standard Specifications for Road and Bridge Construction”.

2.3 FLAT DRAIN TILE

A. Drain tile shall be 12-inch width, with a compressive strength of 11,400 pounds per square foot, and water flow rate of 21 gallons per minute per foot-width at 1,500 pounds per square foot and a 0.1 gradient.

2.4 MANHOLES

A. Manholes: Shall confirm to MSD Standard Detail for Precast Concrete Manhole.

1. Frames and Grates: Cast Iron, complying with The Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities, Latest Edition.

2.5 HYDRO DYNAMIC SEPARATORS

A. Hydro Dynamic Separators: Downstream Defender conforming to details provided on the plans.

2.6 UNDERGROUND DETENTION CHAMBERS

A. Underground detention chambers: ADS StromTech chamber system conforming to details provided on the plans.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 31 20 00 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

D. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install piping NPS 6 and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
3. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
2. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 MANHOLE INSTALLATION

A. Install manholes per Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities, Latest Edition.

3.5 CONNECTIONS

A. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
3. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

B. Pipe couplings and expansion joints with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.

    a. Unshielded flexible couplings for same or minor difference OD pipes.

3.6 IDENTIFICATION

A. Materials and their installation are specified in Section 31 20 00 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.7 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    b. Option: Test plastic piping according to ASTM F 1417.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 33 41 00

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
MISSOURI CLEAN WATER COMMISSION

APPENDIX A

MISSOURI STATE OPERATING PERMIT

General Operating Permit

In compliance with the Missouri Clean Water Law, (Chapter 644 R.S. Mo as amended, hereinafter, the Law), and the Federal Water Pollution Control Act (Public Law 92-500, 92nd Congress) as amended,

Permit No	MOR100038
Owner:	OA-Facilities Mgmt, Design, and Construc
Address:	301 West High Street, Hst Rm 370 Jefferson City, MO 65101
Continuing Authority:	OA Facilities Mgmt Design Construction 301 West High St. HST SOB Rm 730 Jefferson City, MO 65102
Facility Name:	Office of Administration
Facility Address:	OA-FMDC, PO Box 809 301 W High street JEFFERSON CITY, MO 65102
Legal Description:	Land Grant 02681, Cole County
UTM Coordinates:	571840.000/4270368.000
Receiving Stream:	Tributary to Wears Creek (U)
First Classified Stream - ID#:	100K Extent-Remaining Streams (C) 3960.00
USGS# and Sub Watershed#:	10300102 - 1304

is authorized to discharge from the facility described herein, in accordance with the effluent limitations and monitoring requirements as set forth herein.

FACILITY DESCRIPTION

All Outfalls SIC #1629

All Outfalls - Construction or land disturbance activity (e.g., clearing, grubbing, excavating, grading, filling and other activity that results in the destruction of the root zone and/or land disturbance activity that is reasonably certain to cause pollution of waters of the state)
Issued to a city, county, state or federal agency, other governmental jurisdiction, or other private area-wide projects as determined by the Department on a case-by-case basis

This permit authorizes only wastewater, including storm water, discharges under the Missouri Clean Water Law and the National Pollutant Discharge Elimination System, it does not apply to other regulated areas. This permit may be appealed in accordance with RSMo Section 644.051.6 and 621.250, 10 CSR 20-6.020, and 10 CSR 20-1.020.

August 01, 2022
Issue Date

Chris Wieberg, Director
Water Protection Program

July 04, 2027
Expiration Date

I. APPLICABILITY

A. Permit Coverage and Authorized Discharges

1. This Missouri State Operating Permit (permit) authorizes the discharge of stormwater and certain non-stormwater discharges from land disturbance sites that disturb one or more acres, or disturb less than one acre when part of a larger common plan of development or sale that will disturb a cumulative total of one or more acres over the life of the project.

   A Missouri State Operating Permit must be issued before any site vegetation is removed or the site disturbed. Any site owner/operator subject to these requirements for stormwater discharges and who disturbs land prior to permit issuance from the Missouri Department of Natural Resources (Department) is in violation of both State regulations per 10 CSR 20-6.200(1)(A) and Federal regulations per 40 CFR 122.26. The owner/operator of this permit is responsible for compliance with this permit [10 CSR 20-6.200 (3)(B)].

2. This general permit is issued to a city, county, state or federal agency, other governmental jurisdiction, or other private area-wide projects as determined by the Department on a case-by-case basis, for land disturbance projects performed by or under contract to the permittee.

3. This permit authorizes stormwater discharges from land disturbance support activities (e.g., equipment staging yards, material storage areas, excavated material disposal areas, borrow areas, concrete, or asphalt batch plants) provided appropriate stormwater controls are designed, installed, and maintained and the following conditions are met and addressed in the Stormwater Pollution Prevention Plan (SWPPP). The permittee is responsible for compliance with this permit for any stormwater discharges from construction support activity.
   (a) The support activity is directly related to the construction site required to have permit coverage for stormwater discharges;
   (b) The support activity is not a commercial operation or serve multiple unrelated construction sites;
   (c) The support activity does not continue to operate beyond the completion of the construction activity at the project it supports;
   (d) Sediment and erosion controls are implemented in accordance with the conditions of this permit; and
   (e) The support activity is strictly stormwater discharges or non-stormwater discharges listed in PART I, APPLICABILTY, Condition A.4. Support activities which discharge process water shall apply for separate coverage (e.g.,a concrete batch plant discharging process water shall be covered under a MOG49).

4. This permit authorizes non-stormwater discharges associated with your construction activity from the following activities provided that these discharges are treated by appropriate Best Management Practices (BMPs) where applicable and addressed in the permittee's site specific SWPPP required by this general permit:
   (a) Discharges from emergency fire-fighting activities;
   (b) Hydrant flushing and water line flushing, provided the discharged water is managed to avoid instream water quality impacts;
   (c) Landscape watering, including to establish vegetation;
   (d) Water used to control dust;
   (e) Waters used to rinse vehicles and equipment, provided there is no discharge of soaps, solvents, or detergents used for such purposes;
   (f) External building washdown, provided soaps, solvents, and detergents are not used, and external surfaces do not contain hazardous substances (e.g., paint or caulk containing polychlorinated biphenyls (PCBs))
   (g) Pavement wash waters, provided spills or leaks of toxic or hazardous substances have not occurred (unless all spill material has been removed) and where soaps, solvents, and detergents are not used. Directing pavement wash waters directly into any water of the state, storm drain inlet, or stormwater conveyance (constructed or natural site drainage features), unless the conveyance is connected to an effective control, is prohibited;
   (h) Uncontaminated air conditioning or compressor condensate;
   (i) Uncontaminated, non-turbid discharges of ground water or spring water;
   (j) Foundation or footing drains where flows are not contaminated with process materials; and
   (k) Uncontaminated construction dewatering water discharged in accordance with requirements found in this permit for specific dewatering activities.

B. Permit Restrictions and Limitations

1. This permit does not authorize the discharge of process wastewaters, treated or otherwise.

2. For sites operating within the watershed of any Outstanding National Resource Water (which includes the Ozark National Riverways and the National Wild and Scenic Rivers System), sites that discharge to an Outstanding State Resource Water, or facilities located within the watershed of an impaired water as designated in the Clean Water Act (CWA) Section 303(d) list with an impairment for sedimentation/siltation:
   (a) This permit authorizes stormwater discharge provided no degradation of water quality occurs due to discharges from the permitted facility per 10 CSR 20-7.031(3)(C).
   (b) A site with a discharge found to be causing degradation or contributing to an impairment by discharging a pollutant of concern, during an inspection or through complaint investigations, may be required to become a no discharge facility or obtain a site-specific permit with more stringent monitoring and SWPPP requirements.

3. This permit does not allow placement of fill material into any stream or wetland, alteration of a stream channel, or obstruction of stream flow unless the appropriate CWA Section 404 permitting authority provides approval for such actions or determines such actions are exempt from Section 404 jurisdiction. Additionally, this permit does not authorize placement of fill in floodplains unless approved or determined exempt by appropriate federal and/or state floodplain development authorities.

4. This operating permit does not affect, remove, or replace any requirement of the National Environmental Policy Act; the Endangered Species Act; the National Historic Preservation Act; the Comprehensive Environmental Response, Compensation and Liability Act; the Resource Conservation and Recovery Act; or any other relevant acts. Determination of applicability to the above mentioned acts is the responsibility of the permittee. Additionally, this permit does not establish terms and conditions for runoff resulting from silvicultural activities listed in Section 402(l)(3)(a) of the Clean Water Act.

5. Compliance with all requirements in this permit does not supersede any requirement for obtaining project approval from an established local authority nor remove liability for compliance with county and other local ordinances.

6. The Department may require any facility or site authorized by a general permit to apply for a site-specific permit [10 CSR 20-6.010(13)(C)].

7. If a facility or site covered under a current general permit desires to apply for a site-specific permit, the facility or site may do so by contacting the Department for application requirements and procedures.

8. Any discharges not expressly authorized in this permit and not clearly disclosed in the permit application cannot become authorized or shielded from liability under CWA section 402(k) or Section 644.051.16, RSMo, by disclosure to EPA, state, or local authorities after issuance of this permit via any means, including any other permit applications, funding applications, the SWPPP, discharge monitoring reporting, or during an inspection. Discharges at the facility not expressly authorized by this permit must be covered by another permit, be exempt from permitting, or be authorized through some other method.

II. EXEMPTIONS FROM PERMIT REQUIREMENTS

1. Sites that discharge all stormwater runoff directly to a combined sewer system (as defined in 40 CFR 122.26 and 40 CFR 35.2005) connecting to a publicly owned treatment works which has consented to receive such a discharge are exempt from Department stormwater permit requirements.

2. Land disturbance activities that disturb less than one (1) acre of total land area which are not part of a common plan or sale where water quality standards are not exceeded are exempt from Department stormwater permit requirements.

3. Oil and gas related activities as listed in 40 CFR 122.26(a)(2)(ii) where water quality standards are not exceeded are exempt from Department stormwater permit requirements.

4. Linear, strip, or ribbon construction or maintenance operations meeting one (1) of the following criteria are exempt from Department stormwater permit requirements:
   (a) Grading of existing dirt or gravel roads which does not increase the runoff coefficient and the addition of an impermeable surface over an existing dirt or gravel road;
   (b) Cleaning or routine maintenance of roadside ditches, sewers, waterlines, pipelines, utility lines, or similar facilities;
   (c) Trenches two (2) feet in width or less; or
   (d) Emergency repair or replacement of existing facilities as long as BMPs are employed during the emergency repair.

III. REQUIREMENTS

1. The permittee shall post a public notification sign at the main entrance to the site, or a publically visible location, with the specific MOR100 permit number. The public notification sign must be visible from the public road that provides access to the site's main entrance. An alternate location is acceptable provided the public can see it and it is noted in the SWPPP. The public notification sign must remain posted at the site until the site is finalized.

2. The permittee shall be responsible for notifying the land owner and each contractor or entity (including utility crews and city employees or their agents) who will perform work at the site of the existence of the SWPPP and what actions or precautions shall be taken while on site to minimize the potential for erosion and the potential for damaging any BMP. The permittee is responsible for any damage a subcontractor may do to established BMPs and any subsequent water quality violation resulting from the damage.

3. Ensure the design, installation, and maintenance of effective erosion and sediment controls to minimize the discharge of pollutants. At a minimum, such controls must be designed, installed, and maintained to:
   (a) Control stormwater volume, velocity, and peak flow rates to minimize soil erosion;
   (b) Control stormwater discharges, including both peak flow rates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion and scour;
   (c) Minimize the amount of exposed soil during construction activity;
   (d) Minimize the disturbance of steep slopes;
   (e) Minimize sediment discharges from the site. Address factors such as:
      1) The amount, frequency, intensity, and duration of precipitation;
      2) The nature of resulting stormwater runoff;
      3) Expected flow from impervious surfaces, slopes, and drainage features; and
      4) Soil characteristics, including the range of soil particle size expected to be present on the site.
   (f) Provide and maintain natural buffers around surface waters as detailed in Part V. BMP REQUIREMENTS Condition 7, direct stormwater to vegetated areas to increase sediment removal and maximize stormwater infiltration and filtering, unless infeasible; and
   (g) Minimize soil compaction and preserve topsoil where practicable.

   A 2-year, 24-hour storm event can be determined for the project location using the National Oceanic and Atmospheric Administration's National Weather Service Atlas 14 which can be located at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html, or the permittee can determine local rainfall distribution for a 2-year, 24 hours storm event using multi-decade local high density rain gauge data, as approved by the Department.

4. BMPs for land disturbance [10 CSR 20-6.200(1)(D)2] are a schedule of activities, practices, or procedures that reduces the amount of soil available for transport or a device that reduces the amount of suspended solids in runoff before discharge to waters of the state. The term BMPs are also used to describe the sediment and erosion controls and other activities used to prevent stormwater pollution. BMPs are divided into two main categories: structural or non-structural; and they are also classified as temporary or permanent.
   Temporary BMPs may be added and removed as necessary with updates to the SWPPP as specified in the requirements below.

5. Installation of BMPs necessary to prevent soil erosion and sedimentation at the downgradient project boundary (e.g. buffers, perimeter controls, exit point controls, storm drain inlet protection) must be complete prior to the start of all phases of construction. By the time construction activity in any given portion of the site begins, downgradient BMPs must be installed and operational to control discharges from the initial site clearing, grading, excavating, and other earth-disturbing activities. Additional BMPs shall be installed as necessary throughout the life of the project.

6. All BMPs shall be maintained and remain in effective operating condition during the entire duration of the project, with repairs made within the timeframes specified elsewhere in this permit, until final stabilization has been achieved.
   (a) Ensure BMPs are protected from activities that would reduce their effectiveness.
   (b) Remove any sediment per the BMP manufacturer's instructions or before it has accumulated to one-half of the above-ground height of any BMP that collects sediment (i.e., silt fences, sediment traps, etc.)
   (c) The project is considered to achieve final stabilization when Part V. BMP REQUIREMENTS, Condition 13 is met.

7. Minimize sediment trackout from the site and sediment transport onto roadways.
   (a) Restrict vehicle traffic to designated exit points.
   (b) Use appropriate stabilization techniques or BMPs at all points that exit onto paved roads or areas outside of the site.
   (c) Use additional controls or BMPs to remove sediment from vehicle and equipment tires prior to exit from facility where necessary.
   (d) Any sediment or debris that is tracked out past the exit pad or is deposited on a roadway after a precipitation event shall be removed by the shorter of either the same business day (for business days only), or by the end of the next business day if track-out occurs on a non-business day, and before predicted rain events. Remove the track-out sediment by sweeping, shoveling, or vacuuming these surfaces, or by using other similarly effective means of sediment removal. Sediment or debris tracked out on pavement or other impervious surfaces shall not be disposed of into any stormwater conveyance, storm drain inlet, or water of the state.
   (e) Stormwater inlets susceptible to receiving sediment or other pollutants from the permitted land disturbance site shall have curb inlet protection. This may include inlets off the active area where track out from vehicles and equipment could impact the stormwater runoff to those inlets.

8. Concrete washout facilities shall be used to contain concrete waste from the activities onsite, unless the washout of trucks and equipment is managed properly at an off-site location.
   The washout facility shall be managed to prevent solid and/or liquid waste from entering waters of the state by the following:
   (a) Direct the wash water into leak-proof containers or pits designed so that no overflows can occur due to inadequate sizing or precipitation;
   (b) Locate washout activities away from waters of the state, stormwater inlets, and/or stormwater conveyances where practicable. If not practicable, use BMPs to reduce risk of waste leaving the washout facility;
   (c) Washout facilities shall be cleaned, or new facilities must be constructed and ready for use, once the washout is 75% full;
   (d) Designate the washout area(s) and conduct such activities only in these areas.
   (e) Ensure contractors are aware of the location, such as by marking the area(s) on the map or signage visible to the truck and/or equipment operators.

9. Good housekeeping practices shall be maintained at all times to keep waste from entering waters of the state.
   (a) Provide solid and hazardous waste management practices, including providing trash containers, regular site cleanup for proper disposal of solid waste such as scrap building material, product/material shipping waste, food/beverage containers, spent structural BMPs;
   (b) Provide containers and methods for proper disposal of waste paints, solvents, and cleaning compounds.
   (c) Manage sanitary waste. Portable toilets shall be positioned so that they are secure and will not be tipped or knocked over and so that they are located away from waters of the state and stormwater inlets and stormwater conveyances.
   (d) Ensure the storage of construction materials be kept away from drainage courses, stormwater conveyances, storm drain inlets, and low areas.

10. All fueling facilities present shall at all times adhere to applicable federal and state regulations concerning underground storage, above ground storage, and dispensers.

11. Any hazardous wastes that are generated onsite shall be managed, stored, and transported according to the provisions of the Missouri Hazardous Waste Laws and Regulations.

12. Store all paints, solvents, petroleum products, petroleum waste products, and storage containers (such as drums, cans, or cartons) so they are not exposed to stormwater or provide other prescribed BMPs (such as plastic lids and/or portable spill pans) to prevent the commingling of stormwater with container contents. Commingled water may not be discharged under this permit. Provide spill prevention, control, and countermeasures to contain the spill. Any containment system used to implement this requirement shall be constructed of materials compatible with the substances contained and shall prevent the contamination of groundwater.

13. Implement measures intended to prevent the spillage or loss of fluids, oil, grease, fuel, etc. from vehicles and equipment to thereby prevent the contamination of stormwater from these substances. This may include prevention measures such as, but not limited to, utilizing drip pans under vehicles and equipment stored outdoors, covering fueling areas, using dry clean-up methods, use of absorbents, and cleaning pavement surfaces to remove oil and grease.

14. Spills, Overflows, and Other Unauthorized Discharges.
    (a) Any spill, overflow, or other discharge not specifically authorized in the permit above are unauthorized.
    (b) Should an unauthorized discharge cause or permit any contaminants, other than sediment, or hazardous substance to discharge or enter waters of the state, the unauthorized discharge must be reported to the regional office as soon as practicable but no more than 24 hours after the discovery of the discharge. If the spill or overflow needs to be reported after normal business hours or on the weekend, the facility must call the Department's Environmental Emergency Response hotline at (573) 634-2436. Leaving a message on a Department staff member voice-mail does not satisfy this reporting requirement.
    (c) A record of all spills shall be retained with the SWPPP and made available to the Department upon request.
    (d) Other spills not reaching waters of the state must be cleaned up as soon as possible to prevent entrainment in stormwater but are not required to be reported to the Department.

15. The full implementation of this operating permit shall constitute compliance with all applicable federal and state statutes and regulations in accordance with RSMo 644.051.16 and the CWA §402(k); however, this permit may be reopened and modified or alternatively revoked and reissued to comply with any applicable effluent standard or limitation issued or approved under Clean Water Act §§ 301(b)(2)(C) and (D), 304(b)(2), and 307(a)(2) if the effluent standard or limitation so issued or approved contains different conditions or is otherwise more stringent than any effluent limitation in the permit or controls any pollutant not limited in the permit. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, termination, notice of planned changes, or anticipated non-compliance does not stay any permit condition.

IV. STORMWATER POLLUTION PREVENTION PLAN (SWPPP) MANAGEMENT REQUIREMENTS

1. The primary requirement of this permit is the development and implementation of a SWPPP which incorporates site specific practices to best minimize the soil exposure, soil erosion, and the discharge of pollutants, including solids for each site covered under this permit.

   The purpose of the SWPPP is to ensure the design, implementation, management, and maintenance of BMPs in order to prevent sediment and other pollutants in stormwater discharges associated with the land disturbance activities [40 CFR 122.44 (k)(4)] from entering waters of the state above established general and narrative criteria; compliance with Missouri Water Quality Standards; and compliance with the terms and conditions of this general permit.

   (a) **The SWPPP must be developed and implemented prior to conducting any land disturbance activities and must be specific to the land disturbance activities at the site.**
   (b) The permittee shall fully implement the provisions of the SWPPP required under this permit as a condition of this general permit throughout the term of the land disturbance project. Failure to develop, implement, and maintain a SWPPP may lead to immediate enforcement action.

(c) The SWPPP shall be updated any time site conditions warrant adjustments to the project or BMPs.
(d) Either an electronic copy or a paper copy of the SWPPP, and any required reports, must be accessible to anyone on site at all times when land disturbance operations are in process or other operational activities that may affect the maintenance or integrity of the BMP structures and made available as specified under Part VIII. STANDARD PERMIT CONDITIONS, Condition 1 of this permit. The SWPPP shall be readily available upon request and should not be sent to the Department unless specifically requested

2. Failure to implement and maintain the BMPs chosen, which can be revised and updated, is a permit violation. The chosen BMPs will be the most reasonable and cost effective while also ensuring the highest quality water discharged attainable for the facility. Facilities with established SWPPPs and BMPs shall evaluate BMPs on a regular basis and change the BMPs as needed if there are BMP deficiencies.

3. The SWPPP must:
   (a) List and describe the location of all outfalls;
   (b) List any allowable non-stormwater discharges occurring on site and where these discharges occur;
   (c) Incorporate required practices identified below;
   (d) Incorporate sediment and erosion control practices specific to site conditions;
   (e) Discuss whether or not a 404 Permit is required for the project; and
   (f) Name the person(s) responsible for inspection, operation, and maintenance of BMPs. The SWPPP shall list the names and describe the role of all owners/primary operators (such as general contractor, project manager) responsible for environmental or sediment and erosion control at the land disturbance site.

4. The SWPPP briefly must describe the nature of the land disturbance activity, including:
   (a) The function of the project (e.g., low density residential, shopping mall, highway, etc.);
   (b) The intended sequence and timing of activities that disturb the soils at the site; and
   (c) Estimates of the total area expected to be disturbed by excavation, grading, or other land disturbance support activities including off-site borrow and fill areas;

5. In order to identify the site, the SWPPP shall include site information including size in acres. The SWPPP shall have sufficient information to be of practical use to contractors and site construction workers to guide the installation and maintenance of BMPs.

6. The function of the SWPPP and the BMPs listed therein is to prevent or minimize pollution to waters of the state. A deficiency of a BMP means it was not effective in preventing or minimizing pollution of waters of the state.

   The permittee shall select, install, use, operate and maintain appropriate BMPs for the permitted site. The following manuals are acceptable resources for the selection of appropriate BMPs.

   Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites, (Document number EPA 833-R-06-004) published by the United States Environmental Protection Agency (USEPA) in May 2007. This manual as well as other information, including examples of construction SWPPPs, is available at the USEPA internet site at https://www.epa.gov/sites/production/files/2015-10/documents/sw_swppp_guide.pdf; and https://www.epa.gov/npdes/developing-stormwater-pollution-prevention-plan-swppp.

   The latest version of *Protecting Water Quality: A field guide to erosion, sediment and stormwater best management practices for development sites in Missouri,* published by the Department. This manual is available at: https://dnr.mo.gov/document-search/protecting-water-quality-field-guide.

   The permittee is not limited to the use of these guidance manuals. Other guidance publications may be used to select appropriate BMPs. However, all BMPs must be described and justified in the SWPPP. Although the use of these manuals or other resources is recommended and may be used for BMP selection, they do not supersede the conditions of this permit. They may be used to inform in the decision making process for BMP selection but they are not themselves part of the permit conditions.

The permittee may retain the SWPPP, inspection reports, and all other associated documents (including a copy of this permit) electronically pursuant to RSMo 432.255. The documents must be made available to all interested persons in either paper or electronic format as required by this permit and the permittee must remit a copy (electronic or otherwise) of the SWPPP and inspection reports to the Department upon request.

7. The SWPPP must contain a legible site map, multiple maps if necessary, identifying:
   (a) Site boundaries of the property;
   (b) Locations of all waters of the state (including wetlands) within the site and half a mile downstream of the site's outfalls;
   (c) Location of all outfalls;
   (d) Direction(s) of stormwater flow (use arrows) and approximate slopes before and after grading activities;
   (e) Areas of soil disturbance and areas that will not be disturbed (or a statement that all areas of the site will be disturbed unless otherwise noted);
   (f) Location of structural and non-structural BMPs, including natural buffer areas, identified in the SWPPP;
   (g) Locations where stabilization practices are expected to occur;
   (h) Locations of on-site and off-site material, waste, borrow, or equipment storage areas and stockpiles;
   (i) Designated points where vehicles will exit the site;
   (j) Location of stormwater inlets and conveyances including ditches, pipes, man-made conduits, and swales; and
   (k) Areas where final stabilization has been achieved.

8. An individual shall be designated by the permittee as the environmental lead. This environmental lead shall have knowledge in erosion, sediment, and stormwater control principles, knowledge of the permit, and the site's SWPPP. The environmental lead shall ensure all personnel and contractors understand any requirements of this permit may be affected by the work they are doing. The environmental lead or designated inspector(s) knowledgeable in erosion, sediment, and stormwater control principles shall inspect all structures that function to prevent or minimize pollution of waters of the state.

9. Throughout coverage under this permit, the permittee shall amend and update the SWPPP as appropriate during the term of the land disturbance activity. All SWPPP modifications shall be signed and dated. The permittee shall amend the SWPPP to incorporate any significant site condition changes which impact the nature and condition of stormwater discharges. At a minimum, these changes include whenever the:
   (a) Location, design, operation, or maintenance of BMPs is changed;
   (b) Design of the construction project is changed that could significantly affect the quality of the stormwater discharges;
   (c) The permittee's inspections indicate deficiencies in the SWPPP or any BMP;
   (d) Department notifies the permittee in writing of deficiencies in the SWPPP;
   (e) SWPPP is determined to be ineffective in minimizing or controlling erosion and sedimentation (e.g., there is visual evidence of excessive site erosion or sediment deposits in streams, lakes, or downstream waterways, sediment or other wastes off site); and/or
   (f) Department determines violations of water quality standards may occur or have occurred.

10. Site Inspections: The environmental lead, or a designated inspector, shall conduct regularly scheduled inspections. These inspections shall be conducted by a qualified person, one who is responsible for environmental matters at the site, or a person trained by and directly supervised by the person responsible for environmental matters at the site. Site inspections shall include, at a minimum, the following:
   (a) For disturbed areas that have not achieved final stabilization, all installed BMPs and other pollution control measures shall be inspected to ensure they are properly installed, appear to be operational, and are working as intended to minimize the discharge of pollutants.
   (b) For areas on site that have achieved either temporary or final stabilization, while at the same time active construction continues on other areas, ensure that all stabilization measures are properly installed, appear to be operational, and are working as intended to minimize the discharge of pollutants.
   (c) Inspect all material, waste, borrow, and equipment storage and maintenance areas that are covered by this permit. Inspect for conditions that could lead to spills, leaks, or other accumulations of pollutants on the site.
   (d) Inspect all areas where stormwater typically flows within the site, including drainage ways designed to divert, convey, and/or treat stormwater.

(e) All stormwater outfalls shall be inspected for evidence of erosion, sediment deposition, or impacts to the receiving stream. If a discharge is occurring during an inspection, the inspector must observe and document the visual quality of the discharge and take note of the characteristics of the stormwater discharge, including turbidity, color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of stormwater pollutants.
(f) When practicable the receiving stream shall also be inspected for a minimum of 50 feet downstream of the outfall.
(g) The perimeter of the site shall be inspected for evidence of BMP failure to ensure concentrated flow does not develop a new outfall.
(h) The SWPPP must explain how the environmental lead will be notified when stormwater runoff occurs.

11. Inspection Frequency: All BMPs must be inspected in accordance to one of the schedules listed below. The inspection frequency shall be documented in the SWPPP, and any changes to the frequency of inspections, including switching between the options listed below, must be documented on the inspection form:
(a) At least once every seven (7) calendar days and within 48 hours after any storm event equal to or greater than a 2-year, 24-hour storm has ceased during a normal work day or within 72 hours if the rain event ceases during a non-work day such as a weekend or holiday; or
(b) Once every 14 calendar days and within 24 hours of the occurrence of a storm event of 0.25 inches of precipitation or greater, or the occurrence of runoff from snowmelt. To determine if a storm event of 0.25 inches or greater has occurred on the site, the permittee shall either keep a properly maintained rain gauge on site, or obtain the storm event information from a weather station near the site location.
1) Inspections are only required during the project's normal working hours.
2) An inspection must be conducted within 24 hours of a storm event which has produced 0.25 inches. The inspection shall be conducted within 24 hours of the event end, or within 72 hours if the rain event ceases during a non-work day such as a weekend or holiday.
3) If it is elected to inspect every 14 calendar days and there is a storm event at the site that continues for multiple days, and each day of the storm produces 0.25 inches or more of rain, the permittee shall conduct an inspection within 24 hours of the end of the storm or within 72 hours if the rain event ceases during a non-work day such as a weekend or holiday.
(c) Areas on site that have achieved stabilization, while at the same time active construction continues on other areas, may reduce inspection frequency to monthly, for those stabilized areas, if the following conditions exist:
1) For areas where disturbed portions have undergone temporary stabilization, inspections shall occur at least once a month while stabilized and when re-disturbed shall follow either frequency outlined in (a),(b), or (c) above.
2) Areas on site that have achieved final stabilization must be inspected at least once per month until the permit is terminated.
(d) If construction activities are suspended due to frozen conditions, the permittee may temporarily reduce site inspections to monthly until thawing conditions begin to occur if all of the following are met:
1) Land disturbances have been suspended; and
2) All disturbed areas of the site have been stabilized in accordance with Part V. BMP REQUIREMENTS, Condition 13.
3) The change shall be noted in the SWPPP.
(e) Any basin dewatering shall be inspected daily when discharge is occurring. The discharge shall be observed and dewatering activities shall be ceased immediately if the receiving stream is being impacted. These inspections shall be noted on a log or on the inspection report.

If weather conditions or other issues prevent correction of BMPs within seven calendar days, the reasons for the delay must be documented (including pictures), and there must be a narrative explaining why the work cannot be accomplished within the seven day time period. The documentation must be filed with the regular inspection reports. The corrections shall be made as soon as weather conditions or other issues allow.

12. Site Inspection Reports: A log of each inspection and/or copy of the inspection report shall be kept readily accessible and must be made available upon request by the Department. Electronic logs are acceptable as long as reports can be provided within 24 hours. If inspection reports are kept off site, the SWPPP must indicate where they are stored. The inspection report shall be signed by the environmental lead or designated inspector (electronically or otherwise).
(a) The inspection report is to include the following minimum information:
1) Inspector's name and title.
2) Date and time of inspection.
3) Observations relative to the effectiveness of the BMPs and stabilization measures. The following must be

documented:
a. Whether BMPs are installed, operational, and working as intended;
b. Whether any new or modified stormwater controls are needed;
c. Facilities examined for conditions that could lead to spill or leak;
d. Outfalls examined for visual signs of erosion or sedimentation at outfalls. Excessive erosion or sedimentation may be due to BMP failure or insufficiency. Response to observations should be addressed in the inspection report.

4) Corrective actions taken or necessary to correct the observed problem.
5) Listing of areas where land disturbance operations have permanently or temporarily stopped.

13. Any structural or maintenance deficiencies for BMPs or stabilization measures shall be documented and corrected as soon as possible but no more than seven (7) calendar days after the inspection.
(a) Corrective action documentation shall be stored with the associated site inspection report.
(b) Immediately take all reasonable steps to address the condition, including cleaning up any contaminated surfaces so the material will not discharge in subsequent storm events.
(c) If weather conditions or other issues prevent correction of BMPs within seven calendar days, the reasons for the delay must be documented (this may include pictures) and there must be a narrative explaining why the work cannot be accomplished within the seven day time period. The permittee shall correct the problem as soon as weather conditions or issues allow.
(d) Corrective actions may be required by the Department. The permittee must comply with any corrective actions required by the Department as a result of permit violations found during an inspection.

V. BMP REQUIREMENTS

1. The information, practices, and BMP requirements in this section shall be implemented on site and, where noted, provided for in the SWPPP.

2. Existing vegetation and trees shall be preserved where practicable. The permittee is encouraged to preserve topsoil where practicable.

3. The permittee shall select appropriate BMPs for use at the site and list them in the SWPPP. When selecting effective BMPs, the permittee shall consider stormwater volume and velocity. A BMP that has demonstrated ineffectiveness in preventing or minimizing sediment or other pollutants from leaving a given site shall be replaced with a more effective BMP, or additional and sequential BMPs and treatment devices may be incorporated as site conditions allow. The permittee should consider a schedule for performing erosion control measures when selecting BMPs.

4. The SWPPP shall include a description of both structural and non-structural BMPs that will be used at the site.
(a) The SWPPP shall provide the following general information for each BMP which will be used one or more times at the site:
1) Physical description of the BMP;
2) Site conditions that must be met for effective use of the BMP;
3) BMP installation/construction procedures, including typical drawings; and
4) Operation and maintenance procedures and schedules for the BMP.
(b) The SWPPP shall provide the following information for each specific instance where a BMP is to be installed:
1) Whether the BMP is temporary or permanent;
2) When the BMP will be installed in relation to each phase of the land disturbance procedures to complete the project; and
3) Site conditions that must be met before removal of the BMP if the BMP is not a permanent BMP.

5. Structural BMP Installation: The permittee shall ensure all BMPs are properly installed and operational at the locations and relative times specified in the SWPPP.
(a) Perimeter control BMPs for runoff from disturbed areas shall be installed before general site clearing is started. Note this requirement does not apply to earth disturbances related to initial site clearing and establishing entry, exit, or access of the site, which may require that stormwater controls be installed immediately after the earth

disturbance.
(b) For phased projects, BMPs shall be properly installed as necessary prior to construction activities.
(c) Stormwater discharges which leave the site from disturbed areas shall pass through an appropriate impediment to sediment movement such as a sedimentation basin, sediment traps (including vegetative buffers), or silt fences prior to leaving the land disturbance site.
(d) A drainage course change shall be clearly marked on a site map and described in the SWPPP.
(e) If vegetative stabilization measures are being implemented, stabilization efforts are considered "installed" when all activities necessary to seed or plant the area are completed. Vegetative stabilization is not considered "operational" until the vegetation is established.

6. Install sediment controls along any perimeter areas of the site that are downgradient from any exposed soil or other disturbed areas. Prevent stormwater from circumventing the edge of the perimeter control. For sites where perimeter controls are infeasible, other practices shall be implemented to minimize discharges to perimeter areas of the site.

7. For surface waters of the state, defined in Section 644.016.1(27) RSMo, located on or adjacent to the site, the permittee must maintain a riparian buffer or structural equivalent in accordance with at least one of the following options. The selection and location must be described in the SWPPP.
   (a) Provide and maintain a 50-foot undisturbed natural buffer; or
   (b) Provide and maintain an undisturbed natural buffer that is less than 50 feet and is supplemented by erosion and sediment controls that achieve the sediment load reduction equivalent to a 50-foot undisturbed natural buffer; or
   (c) If infeasible to provide and maintain an undisturbed natural buffer of any size, implement erosion and sediment controls to achieve the sediment load reduction equivalent to a 50-foot undisturbed natural buffer.
   (d) The permittee is not required to comply with (a), (b), or (c) above if one or more of the following exceptions apply and documentation is provided in the SWPPP:
      1) As authorized per CWA Section 404 Department of the Army permit and its associated Section 401 Water Quality Certification from the Department.
      2) If there is no discharge of stormwater to waters of the state through the area between the disturbed portions of the site and waters of the state located within 50 feet of the site. This includes situations where the permittee has implemented permanent control measures that will prevent such discharges, such as a berm or other barrier.
      3) Where no natural buffer exists due to preexisting development disturbances that occurred prior to the initiation of planning for the current development of the site.
         a. Where some natural buffer exists but portions of the area within 50 feet of the waters of the state are occupied by preexisting development disturbances the permittee is required to comply with (a), (b), or (c) above.
      4) For linear projects where site constraints make it infeasible to implement a buffer or equivalent provided the permittee limit disturbances within 50 feet of any waters of the state and/or the permittee provides supplemental erosion and sediment controls to treat stormwater discharges from earth disturbances within 50 feet of the water of the state. The permittee must also document in the SWPPP the rationale for why it is infeasible for the permittee to implement (a), (b), or (c) and describe any buffer width retained and supplemental BMPs installed.
   (e) Where the permittee is retaining a buffer of any size, the buffer should be measured perpendicularly from any of the following points, whichever is further landward from the water:
      1) The ordinary high water mark of the water body, defined as the line on the shore established by fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, and/or the presence of litter and debris; or
      2) The edge of the stream or river bank, bluff, or cliff, whichever is applicable.

8. Slopes for disturbed areas must be identified in the SWPPP. A site map or maps defining the sloped areas for all phases of the project must be included in the SWPPP. The disturbance of steep slopes shall be minimized.
9. Manage stockpiles or land clearing debris piles composed, in whole or in part, of sediment and/or soil.
   (a) Locate the piles outside of any natural buffers zones, established under the condition above, and away from any stormwater conveyances, drain inlets, and areas where stormwater flow is concentrated;
   (b) Install a sediment barrier along all downgradient perimeter areas;
   (c) Divert surface flows around stockpiles to reduce and minimize erosion of the stockpile.

(d) For piles that will be unused for 14 or more days, provide cover with appropriate temporary stabilization in accordance with Part V. BMP REQUIREMENTS, Condition 13.
(e) Rinsing, sweeping, or otherwise placing any soil, sediment, debris, or stockpiled product which has accumulated on pavement or other impervious surfaces into any stormwater conveyance, storm drain inlet, or water of the state is prohibited.

10. The site shall include BMPs for pollution prevention measures and shall be noted in the SWPPP. At minimum such measures must be designed, installed, implemented, and maintained to:
(a) Minimize the discharge of pollutants from equipment and vehicle rinsing; no detergents, additives, or soaps of any kind shall be discharged. Rinse waters must be treated in a sediment basin or alternative control that provides equivalent or better treatment prior to discharge;
(b) Minimize the exposure of building materials, building products, construction wastes, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on the site to precipitation and to stormwater;
(c) Minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures, including, but not limited to, the installation of containment berms and use of drip pans at petroleum product and liquid storage tanks and containers; and
(d) Prevent discharges from causing or contributing to an exceedance of water quality standards including general criteria.

11. Sedimentation Basins: The SWPPP shall include a sedimentation basin for each drainage area with ten or more acres disturbed at one time.
(a) The sedimentation basin shall be sized, at a minimum, to treat a local 2-year, 24-hour storm.
(b) Sediment basins shall not be constructed in any waters of the state or natural buffer zones.
(c) Discharges from dewatering activities shall be managed by appropriate controls. The SWPPP shall include a description of any anticipated dewatering methods and specific BMPs designed to treat dewatering water.
    1) Appropriate controls include, but are not limited to, sediment socks, dewatering tanks, tube settlers, weir tanks, filtration systems (e.g. bag or sand filters), and passive treatment systems that are designed to remove or retain sediment.
    2) Erosion controls and velocity dissipation devices (e.g., check dams, riprap, and vegetated buffers) to minimize erosion at inlets, outlets, and discharge points from shall be utilized.
    3) Water with an oil sheen shall not be discharged and shall be marked in SWPPP.
    4) Visible floating solids and foam shall not be discharged.
(d) Until final stabilization has been achieved, sediment basins and impoundments shall utilize outlet structures or floating skimmers that withdraw water from the surface when discharging.
    1) Under frozen conditions, it may be considered infeasible to withdraw water from the surface and an exception can be made for that specific period as long as discharges that may contain sediment and other pollutants are managed by appropriate controls. If determined infeasible due to frozen conditions, documentation must be provided in the SWPPP to support the determination, including the specific conditions or time period when this exception applies.
(e) Accumulated sediment shall not exceed 50% of total volume or as prescribed in the design, whichever is less. Note in the SWPPP the locations for disposal of the material removed from sediment basins.
(f) Prevent discharges to the receiving stream causing excessive visual turbidity. For the purposes of this permit, visual turbidity refers to a sediment plume or other cloudiness in the water caused by sediment that can be identified by an observer.
(g) The SWPPP shall require the basin be maintained until final stabilization of the disturbed area served by the basin.

Where use of a sediment basin is infeasible, the SWPPP shall evaluate and specify other similarly effective BMPs to be employed to control erosion and sediment. These similarly effective BMPs shall be selected from appropriate BMP guidance documents authorized by this permit. The BMPs must provide equivalent water quality protection to achieve compliance with this permit. The SWPPP shall require both temporary and permanent sedimentation basins to have a stabilized spillway to minimize the potential for erosion of the spillway or basin embankment.

12. Soil disturbing activities on site that have ceased either temporarily or permanently shall initiate stabilization immediately in accordance with the options below. For soil disturbing activities that have been temporarily ceased on any portion of the site and will not resume for a period exceeding 14 calendar days:
    (a) The permittee shall construct BMPs to establish interim stabilization; and
    (b) Stabilization must be initiated immediately and completed within 14 calendar days.
    (c) For soil disturbing activities that have been permanently ceased on any portion of the site, final stabilization of disturbed areas must be initiated immediately and completed within 14 calendar days.
        1) Allowances to the 14-day completion period for temporary and final stabilization may be made due to weather and equipment malfunctions. The use of allowances shall be documented in the SWPPP. Allowances may be determined unnecessary after review by the Department.
    (d) Until stabilization is complete, interim sediment control shall consist of well-established and maintained BMPs that are reasonably certain to protect waters of the state from sediment pollution over an extended period of time. This may require adding more BMPs to an area than is normally used during daily operations. The types of BMPs used must be suited to the area disturbed, taking into account the number of acres exposed and the steepness of the slopes. If the slope of the area is greater than 3:1 (three feet horizontal to one foot vertical), then the permittee shall establish interim stabilization within seven days of ceasing operations on that part of the site. The following activities would constitute the immediate initiation of stabilization:
        1) Prepping the soil for vegetative or non-vegetative stabilization as long as seeding, planting, and/or installation of non-vegetative stabilization products takes place as soon as practicable;
        2) Applying mulch or other non-vegetative product to the exposed areas;
        3) Seeding or planting the exposed areas;
        4) Finalizing arrangements to have stabilization product fully installed in compliance with the deadlines for completing stabilization.
    (e) If vegetative stabilization measures are being implemented, stabilization is considered “installed” when all activities necessary to seed or plant the area are completed. Installed does not mean established.
    (f) If non-vegetative stabilization measures are being implemented, stabilization is considered “installed” when all such measures are implemented or applied.
        1) Non-vegetative stabilization shall prevent erosion and shall be chosen for site conditions, such as slope and flow of stormwater.
    (g) Final stabilization is not considered achieved until vegetation has grown and established to meet the requirements below.

13. Prior to removal of BMPs, ceasing site inspections, and removing from the quarterly report, final stabilization must be achieved. Final stabilization shall be achieved as soon as possible once land disturbance activities have ceased. Document in the SWPPP the type of stabilization and the date final stabilization is achieved.
    (a) The project is considered to have achieved final stabilization when perennial vegetation (excluding volunteer vegetation), pavement, buildings, or structures using permanent materials (e.g., riprap, gravel, etc.) cover all areas that have been disturbed. With respect to areas that have been vegetated, vegetation must be at least 70% coverage of 100% of the vegetated areas on site. Vegetation must be evenly distributed.
    (b) Disturbed areas on agricultural land are considered to have achieved final stabilization when they are restored to their preconstruction agricultural use. If former agricultural land is changing to non-agricultural use, this is no longer considered agricultural land and shall follow condition (a).
    (c) If the intended function of a specific area of the site necessitates that it remain disturbed, final stabilization is considered achieved if all of the following are met:
        1) Only the minimum area needed remains disturbed (i.e., dirt access roads, motocross tracks, utility pole pads, areas being used for storage of vehicles, equipment, materials). Other areas must meet the criteria above.

2) Permanent structural BMPs (e.g., rock checks, berms, grading, etc.) or non-vegetative stabilization measures are implemented and designed to prevent sediment and other pollutants from entering waters of the state.
3) Inspection requirements in Part IV. SWPPP MANAGEMENT REQUIREMENT, Condition 11 are met and documented in the SWPPP.

(d) Winter weather and frozen conditions do not excuse any of the above final stabilization requirements. If vegetation is required for stabilization the permittee must maintain BMPs throughout winter weather and frozen conditions until thawing and vegetation meets final stabilization criteria above. Document stabilization attempts during frozen conditions in the SWPPP. Consider future freezing when removing vegetation and plan with temporary stabilization techniques before the ground becomes frozen.

VI. SITE FINALIZATION & PERMIT TERMINATION

1. Until a site is finalized, the permittee must comply with all conditions in the permit, including continuation of site inspections and reporting quarterly to the Department. To finalize the site and remove from this permit coverage, the site shall meet the following requirements:
   (a) For any areas that (1) were disturbed during construction, (2) are not covered over by permanent structures, and (3) over which the permittee had control during the construction activities, the requirements for final vegetative or non-vegetative stabilization in Part V. BMP REQUIREMENTS, Condition 13;
   (b) The permittee has removed and properly disposed of all construction materials, waste, and waste handling devices and has removed all equipment and vehicles that were used during construction, unless intended for long-term beyond construction phase;
   (c) The permittee has removed all temporary BMPs that were installed and maintained during construction, except those that are intended for long-term use or those that are biodegradable; and
   (d) The permittee has removed all potential pollutants and pollutant-generating activities associated with construction, unless needed for long-term use following the construction activities.

2. The permit may be terminated if;
   (a) There has been a transfer of control of all areas of the site for which the current permittee is responsible under this permit to another operator, and that operator has obtained coverage under this permit;
   (b) Active sites obtain coverage under an individual or alternative general NPDES permit, with land disturbance conditions; or
   (c) This permit may be terminated when all projects covered under this permit are finalized. In order to terminate the permit, the permittee shall notify the Department by submitting a Request for Termination along with the final quarterly report for the current calendar quarter.

VII. REPORTING AND SAMPLING REQUIREMENTS

1. The permittee is not required to sample stormwater under this permit. The Department may require sampling and reporting as a result of illegal discharges, compliance issues related to water quality concerns, or evidence of off-site impacts from activities at a site. If such an action is needed, the Department will specify in writing the sampling requirements, including such information as location and extent. If the permittee refuses to perform sampling when required, the Department may terminate the general permit and require the facility to obtain a site-specific permit with sampling requirements.

2. Electronic Discharge Monitoring Report (eDMR) Submission System. The NPDES Electronic Reporting Rule, 40 CFR Part 127, reporting of any report required by the permit shall be submitted via an electronic system to ensure timely, complete, accurate, and nationally consistent set of data for the NPDES program. The eDMR system is currently the only Department-approved reporting method for this permit unless specified elsewhere in this permit, or a waiver is granted by the Department. The facility must register in the Department's eDMR system through the Missouri Gateway for Environmental Management (MoGEM) before the first report is due.

3. Permittees shall prepare a quarterly report with a list of active land disturbance sites including any off-site borrow or depositional areas associated with the construction project and submit the following information electronically as an

attachment to the eDMR system until such a time when the current or a new system is available to allow direct input of the data:

(a) The name of the project;
(b) The location of the project (including the county);
(c) The name of the primary receiving water(s) for each project;
(d) A description of the project;
(e) The number of acres disturbed;
(f) The percent of completion of the project; and
(g) The projected date of completion.

The quarterly report(s) shall be maintained by the permittee and readily available for review by the Department at the address provided on the application as well as submitted quarterly via the Department's eDMR system. The permittee shall submit quarterly reports according to Table A.

Table A	**Schedule for Quarterly Reporting**
Activity for the months of:	Report is due:
January, February, March (1st Quarter)	April 28
April, May, June (2nd Quarter)	July 28
July, August, September (3rd Quarter)	October 28
October, November, December (4th Quarter)	January 28

VIII. STANDARD PERMIT CONDITIONS

1. Records: The permittee shall retain copies of this general permit, the SWPPP and all amendments for the site named in the State Operating Permit, results of any monitoring and analysis, and all site inspection records required by this general permit.
   (a) The records shall be accessible during normal business hours and retained for a period of at least three (3) years from the date of termination.
   (b) The permittee shall provide a copy (electronic or otherwise) of the SWPPP to the Department, USEPA, or any local agency or government representative if they request a copy in the performance of their official duties within 24 hours of the request (or next working day), unless given more time by the representative.
   (c) The permittee shall provide a copy of the SWPPP to those who are responsible for installation, operation, or maintenance of any BMP. The permittee, their representative, and/or the contractor(s) responsible for installation, operation and maintenance of the BMPs shall have a current copy of the SWPPP with them when on the project site.

2. Land Ownership and Change of Ownership: Federal and Missouri stormwater regulations [10 CSR 20-6.200(1) (B)] require a stormwater permit and erosion control measures for all land disturbances of one or more acres. These regulations also require a permit for less than one acre lots if the lot is part of a larger common plan of development or sale where that plan is at least one acre in size.
   (a) If the permittee sells any portion of a permitted site to a developer for commercial, industrial, or residential use, this land remains a part of the common sale and the new owner must obtain a permit prior to conducting any land disturbance activity. Therefore, the original permittee must amend the SWPPP to show that the property has been sold and, therefore, no longer under the original permit coverage.
   (b) Property of any size which is part of a larger common plan of development where the property has achieved final stabilization and the original permit terminated will require application of a new land disturbance permit for any future land disturbance activity unless the activity is by an individual residential building lot owner on a site less than one acre.
   (c) If a portion of a larger common plan of development is sold to an individual for the purpose of building his or her own private residence, a permit is required if the portion of land sold is equal to or greater than one acre. No permit is required, however, for less than one acre of land sold.

3. Permit Transfer: This permit may not be transferred to a new owner.

4. Termination: This permit may be terminated when the project has achieved final stabilization, defined in Part VI. SITE FINALIZATION & PERMIT TERMINATION.
   (a) In order to terminate the permit, the permittee shall notify the Department by submitting the form Request for Termination of Operating Permit Form MO 780-2814. The form should be submitted to the appropriate regional office or through an approved electronic system if it should become available.
   (b) The Cover Page (Certificate Page) of the Master General Permit for Land Disturbance specifies the "effective date" and the "expiration date" of the Master General Permit. The "issued date" along with the "expiration date" will appear on the State Operating Permit issued to the applicant. **This permit does not continue administratively beyond the expiration date.**

5. Duty to Reapply: If the project or development completion date will be after the expiration date of this general permit, then the permittee must reapply to the Department for a new permit. This permit may be applied for and issued electronically in accordance with Section 644.051.10, RSMo.
   (a) Due to the nature of the electronic permitting system, a period of time may be granted at the discretion of the Department in order to apply for a new permit after the new version is effective. Applicants must maintain appropriate best management practices and inspections during the discretionary period.

6. Duty to Comply: The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Missouri Clean Water Law and Federal Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

7. Modification, Revocation, and Reopening:
   (a) If at any time the Department determines that the quality of waters of the state may be better protected by reopening this permit, or revoking this permit and requiring the owner/operator of the permitted site to apply for a site-specific permit, the Department may revoke a general permit and require any person to obtain such an operating permit as authorized by 10 CSR20-6.010(13) and 10 CSR 20-6.200(1)(B).
   (b) If this permit is reopened, modified, or revoked pursuant to this Section, the permittee retains all rights under Chapter 536 and 644 Revised Statutes of Missouri upon the Department's reissuance of the permit as well as all other forms of administrative, judicial, and equitable relief available under law.

8. Other Information: Where the permittee becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

9. Duty to Provide Information: The permittee shall furnish to the Department, within 24 hours unless explicitly granted more time in writing, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish to the Department upon request, copies of records required to be kept by this permit.

10. Inspection and Entry: The permittee shall allow the Department, or an authorized representative (including an authorized contractor acting as a representative of the Department), upon presentation of credentials and other documents as may be required by law, to:
    (a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted or where records must be kept under the conditions of the permit;
    (b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
    (c) Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and
    (d) Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Federal Clean Water Act or Missouri Clean Water Law, any substances or parameters at any location.

11. Signatory Requirement:
    (a) All permit applications, reports required by the permit, or information requested by the Department shall be signed and certified. (See 40 CFR 122.22 and 10 CSR 20-6.010)
    (b) The Federal Clean Water Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit (including monitoring reports or reports of compliance or non-compliance) shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than six (6) months per violation, or by both.
    (c) The Missouri Clean Water Law provides that any person who knowingly makes any false statement, representation or certification in any application, record, report, plan, or other document filed or required to be maintained pursuant to sections 644.006 to 644.141 shall, upon conviction, be punished by a fine of not more than ten thousand dollars, or by imprisonment for not more than six months, or by both.

12. Property Rights: This permit does not convey any property rights of any sort or any exclusive privilege.

13. Notice of Right to Appeal: If you were adversely affected by this decision, you may be entitled to pursue an appeal before the administrative hearing commission (AHC) pursuant to Sections 621.250 and 644.051.6 RSMo. To appeal, you must file a petition with the AHC within thirty days after the date this decision was mailed or the date it was delivered, whichever date was earlier. If any such petition is sent by registered mail or certified mail, it will be deemed filed on the date it is mailed; if it is sent by any method other than registered mail or certified mail, it will be deemed filed on the date it is received by the AHC. Any appeal should be directed to:

Administrative Hearing Commission
U.S. Post Office Building, Third Floor
131 West High Street, P.O. Box 1557
Jefferson City, MO 65102-1557
Phone: 573-751-2422
Fax: 573-751-5018
Website: https://ahc.mo.gov

MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

STORMWATER DISCHARGES FROM THIS LAND DISTURBANCE SITE ARE AUTHORIZED BY THE MISSOURI STATE OPERATING PERMIT NUMBER:

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ANYONE WITH QUESTIONS OR CONCERNS ABOUT STORMWATER DISCHARGES FROM THIS SITE, PLEASE CONTACT THE MISSOURI DEPARTMENT OF NATURAL RESOURCES AT

1-800-361-4827

MISSOURI DEPARTMENT OF NATURAL RESOURCES
FACT SHEET FOR MASTER GENERAL PERMIT
MO-R100XXX

The Federal Water Pollution Control Act [Clean Water Act (CWA)] Section 402 of Public Law 92-500 (as amended) established the National Pollution Discharge Elimination System (NPDES) permit program. This program regulates the discharge of pollutants from point sources into the waters of the United States and the release of stormwater from certain point sources. All such discharges are unlawful without a permit (Section 301 of the CWA). After a permit is obtained, a discharge not in compliance with all permit terms and conditions is unlawful. Missouri State Operating Permits (MSOPs) are issued by the Missouri Department of Natural Resources (Department) under an approved program operated in accordance with federal and state laws (Federal CWA and Missouri Clean Water Law Section 644 as amended). Permits are issued for a period of five (5) years unless otherwise specified.

Per 40 CFR 124.56, 40 CFR 124.8, and 10 CSR 20-6.020(1)(A)2, a Fact Sheet shall be prepared to give pertinent information regarding the applicable regulations, rationale for the development of effluent limitations and conditions, and the public participation process for the permit. A Fact Sheet is not an enforceable part of an MSOP.

DEFINITIONS FOR THE PURPOSES OF THIS PERMIT:

Common Promotional Plan: A plan undertaken by one (1) or more persons to offer lots for sale or lease; where land is offered for sale by a person or group of persons acting in concert, and the land is contiguous or is known, designated, or advertised as a common unit or by a common name or similar names, the land is presumed, without regard to the number of lots covered by each individual offering, as being offered for sale or lease as part of a common promotional plan.

Dewatering: The act of draining rainwater and/or groundwater from basins, building foundations, vaults, and trenches.

Effective Operating Condition: For the purposes of this permit, a stormwater control is kept in effective operating condition if it has been implemented and maintained in such a manner that it is working as designed to minimize pollutant discharges.

Emergency-Related Project: A project initiated in response to a public emergency (e.g. earthquakes, extreme flooding conditions, tornado, disruptions in essential public services, pandemic) for which the related work requires immediate authorization to avoid imminent endangerment to human health/safety or the environment or to reestablish essential public services.

Exposed Soils: For the purposes of this permit, soils that as a result of earth-disturbing activities are left open to the elements.

Immediately: For the purposes of this permit, immediately should be defined as within 24 hours.

Impervious Surface: For the purpose of this permit, any land surface with a low or no capacity for soil infiltration including, but not limited to, pavement, sidewalks, parking areas and driveways, packed gravel or soil, or rooftops.

Infeasible: Infeasible means not technologically possible or not economically practicable and achievable in light of best industry practices.

Install or Installation: When used in connection with stormwater controls, to connect or set in position stormwater controls to make them operational.

Land Disturbance Site or Site: The land or water area where land disturbance activities will occur and where stormwater controls will be installed and maintained. The land disturbance site includes construction support activities, which may be located at a different part of the property from where the primary land disturbance activity will take place or on a different piece of property altogether. Off-site borrow areas directly and exclusively related to the land disturbance activity are part of the site and must be permitted.

Larger Common Plan of Development or Sale: A continuous area where multiple separate and distinct construction activities are occurring under one plan, including any off-site borrow areas that are directly and exclusively related to the land disturbance activity. Off-site borrow areas utilized for multiple different land disturbance projects are considered their own entity and are not part of the larger common plan of development or sale. See definition of Common Promotional Plan to understand what a 'common plan' is.

Minimize: To reduce and/or eliminate to the extent achievable using stormwater controls that are technologically available and economically practicable and achievable in light of best industry practices.

Non-structural Best Management Practices (BMPs): Institutional, educational, or pollution prevention practices designed to limit the amount of stormwater runoff or pollutants that are generated in the landscape. Examples of non-structural BMPs include picking up trash and debris, sweeping up nearby sidewalks and streets, maintaining equipment, and training site staff on stormwater control practices.

Operational: for the purposes of this permit, stormwater controls are made "operational" when they have been installed and implemented, are functioning as designed, and are properly maintained.

Ordinary High Water Mark: The line on the shore established by fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, and/or the presence of litter and debris.

Peripheral: For the purposes of this permit, peripheral should be defined as the outermost boundary of the area that will be disturbed.

Permanently: For the purposes of this permit, permanently is defined as any activity that has been ceased without any intentions of future disturbance.

Pollution Prevention Controls (or Measures): Stormwater controls designed to reduce or eliminate the addition of pollutants to construction site discharges through analysis of pollutant sources, implementation of proper handling/disposal practices, employee education, and other actions.

Qualified Person (inspections): A person knowledgeable in the principles and practice of erosion and sediment controls and pollution prevention who possesses the appropriate skills and training to assess conditions at the construction site that could impact stormwater quality and the appropriate skills and training to assess the effectiveness of any stormwater controls selected and installed to meet the requirements of this permit.

Stormwater Control (also referred to as sediment/erosion controls): refers to any temporary or permanent BMP or other method used to prevent or reduce the discharge of pollutants to waters of the state.

Structural BMP: Physical sediment/erosion controls working individually or as a group (treatment train) appropriate to the source, location, and area climate for the pollutant to be controlled. Examples of structural BMPs include silt fences, sedimentation ponds, erosion control blankets, and seeding.

Temporary Stabilization: A condition where exposed soils or disturbed areas are provided temporary vegetation and/or non-vegetative protective cover to prevent erosion and sediment loss. Temporary stabilization may include temporary seeding, geotextiles, mulches, and other techniques to reduce or eliminate erosion until either final stabilization can be achieved or until further construction activities take place to re-disturb this area.

Treatment Train: A multi-BMP approach to managing the stormwater volume and velocity and often includes erosion prevention and sediment control practices often applied when the use of a single BMP is inadequate in preventing the erosion and transport of sediment. A good option to utilize as a corrective action.

Volunteer Vegetation: A volunteer plant is a plant that grows on its own, rather than being deliberately planted for stabilization purposes. Volunteers often grow from seeds that float in on the wind, are dropped by birds, or are inadvertently mixed into soils. Commonly, volunteer vegetation is referred to as 'weeds'. This does not meet the requirements for final stabilization.

Waters of the State: Section 644.016.1(27) RSMo. defines waters of the state as, "All waters within the jurisdiction of this state, including all rivers, streams, lakes and other bodies of surface and subsurface water lying within or forming a part of the boundaries of the state which are not entirely confined and located completely upon lands owned, leased or otherwise controlled by a single person or by two or more persons jointly or as tenants in common."

PART I – BASIC PERMIT INFORMATION

Facility Type:	Industrial Stormwater; Land Disturbance
Facility SIC Code(s):	1629
Facility Description:	Construction or land disturbance activity (e.g., clearing, grubbing, excavating, grading, filling, and other activities that result in the destruction of the root zone and/or land disturbance activity that is reasonably certain to cause pollution to waters of the state).

This permit establishes a Stormwater Pollution Prevention Plan (SWPPP) requirement for pollutants of concern from this type of facility or for all facilities and sites covered under this permit. 10 CSR 20-6.200(7) specifies "general permits shall contain BMP requirements and/or monitoring and reporting requirements to keep the stormwater from becoming contaminated".

Land disturbance activities include clearing, grubbing, excavating, grading, filling and other activities that result in the destruction of the root zone and/or other activities that are reasonably certain to cause pollution to waters of the state. A Missouri State Operating Permit for land disturbance permit is required for construction disturbance activities of one or more acres or for construction activities that disturb less than one acre when they are part of a larger common plan of development or sale that will disturb a cumulative total of one or more acres over the life of the project.

The primary requirement of a land disturbance permit is the development of a SWPPP which incorporates site-specific BMPs to minimize soil exposure, soil erosion, and the discharge of pollutants. The SWPPP ensures the design, implementation, management, and maintenance of BMPs in order to prevent sediment and other pollutants from leaving the site.

When it precipitates, stormwater washes over the loose soil on a construction site and various other materials and products being stored outside. As stormwater flows over the site, it can pick up pollutants like sediment, debris, and chemicals from the loose soil and transport them to nearby storm sewer systems or directly into rivers, lakes, or coastal waters.

The Missouri Department of Natural Resources is responsible for ensuring that construction site operators have the proper stormwater controls in place so that construction can proceed in a way that protects your community's clean water and the surrounding environment. One way the department helps protect water quality is by issuing land disturbance permits.

Local conditions are not considered when developing conditions for a general permit. A facility may apply for a site-specific permit if they desire a review of site-specific conditions.

PART II – RECEIVING STREAM INFORMATION

APPLICABLE DESIGNATIONS OF WATERS OF THE STATE:
Per Missouri Effluent Regulations (10 CSR 20-7.015), the waters of the state are divided into seven (7) categories. This permit applies to facilities discharging to the following water body categories:

- ✓ Missouri or Mississippi River [10 CSR 20-7.015(2)]
- ✓ Lakes or Reservoirs [10 CSR 20-7.015(3)]
- ✓ Losing Streams [10 CSR 20-7.015(4)]
- ✓ Metropolitan No-Discharge Streams [10 CSR 20-7.015(5)]
- ✓ Special Streams [10 CSR 20-7.015(6)]
- ✓ Subsurface Waters [10 CSR 20-7.015(7)]
- ✓ All Other Waters [10 CSR 20-7.015(8)]

Missouri Water Quality Standards (10 CSR 20-7.031) defines the Clean Water Commission water quality objectives in terms of "water uses to be maintained and the criteria to protect those uses." The receiving stream and/or 1st classified receiving stream's designated water uses shall be maintained in accordance with 10 CSR 20-7.031(24). A general permit does not take into consideration site-specific conditions.

MIXING CONSIDERATIONS:
This permit applies to receiving streams of varying low flow conditions. Therefore, the effluent limitations must be based on the smallest low flow streams considered, which includes waters without designated uses. As such, no mixing is allowed [10 CSR 20-7.031(5)(A)4.B.(I)(a)]. No Zone of Initial Dilution is allowed. [10 CSR 20-7.031(5)(A)4.B.(I)(b)].

RECEIVING STREAM MONITORING REQUIREMENTS:
There are no receiving water monitoring requirements recommended at this time.

PART III – RATIONALE AND DERIVATION OF EFFLUENT LIMITATIONS & PERMIT CONDITIONS

305(B) REPORT, 303(d) LIST, & TOTAL MAXIMUM DAILY LOAD (TMDL):
Section 305(b) of the Federal CWA requires each state identify waters not meeting Water Quality Standards and for which adequate water pollution controls have not been required. Water Quality Standards protect such beneficial uses of water as whole body contact, maintaining fish and other aquatic life, and providing drinking water for people, livestock, and wildlife. The 303(d) list helps state and federal agencies keep track of waters which are impaired but not addressed by normal water pollution control programs.

A TMDL is a calculation of the maximum amount of a given pollutant a body of water can absorb before its water quality is affected. If a water body is determined to be impaired as listed on the 303(d) list, then a watershed management plan will be developed which shall include the TMDL calculation. For facilities with an existing general permit before a TMDL is written on their receiving stream, the Department will evaluate the permit and may require any facility authorized by this general permit to apply for and obtain a site-specific operating permit.

ANTI-BACKSLIDING:
A provision in the Federal Regulations [CWA Section 303(d)(4); CWA Section 402(c); 40 CFR Part 122.44(I)] requires a reissued permit to be as stringent as the previous permit with some exceptions.
✓ Not Applicable: All effluent limitations in this permit are at least as protective as those previously established.

ANTIDEGRADATION:
Antidegradation policies ensure protection of water quality for a particular water body on a pollutant by pollutant basis to ensure Water Quality Standards are maintained to support beneficial uses such as fish and wildlife propagation and recreation on and in the water. This also includes special protection of waters designated as an Outstanding National Resource Water or Outstanding State Resource Water [10 CSR 20-7.031(3)(C)]. Antidegradation policies are adopted to minimize adverse effects on water.

The Department has determined the best avenue forward for implementing the Antidegradation requirements into general stormwater permits is by requiring the appropriate development and maintenance of a SWPPP. The SWPPP must identify all reasonable and effective BMPs, taking into account environmental impacts and costs. This analysis must document why no discharge or no exposure options are not feasible at the facility. This selection and documentation of appropriate control measures will then serve as the analysis of alternatives and fulfill the requirements of the Antidegradation Rule and Implementation Procedure 10 CSR 20-7.031(3) and 10 CSR 20-7.015(9)(A)5.

Any facility seeking coverage under this permit which undergoes expansion or discharges a new pollutant of concern must update their SWPPP and select reasonable and cost effective new BMPs. New facilities seeking coverage under this permit are required to develop a SWPPP including this analysis and documentation of appropriate BMPs. Renewal of coverage for a facility requires a review of the SWPPP to ensure the selected BMPs continue to be appropriate.
✓ Applicable; the facility must review and maintain stormwater BMPs as appropriate.

BENCHMARKS:
When a permitted feature or outfall consists of only stormwater, a benchmark may be implemented at the discretion of the permit writer. Benchmarks require the facility to monitor and, if necessary, replace and update stormwater control measures. Benchmark concentrations are not effluent limitations. A benchmark exceedance, therefore, is not a permit violation; however, failure to take corrective action is a violation of the permit. Benchmark monitoring data is used to determine the overall effectiveness of control measures and to assist the permittee in knowing when additional corrective actions may be necessary to comply with the limitations of the permit.
✓ Not applicable; this permit does not contain numeric benchmarks.

BEST MANAGEMENT PRACTICES (BMPS):
Minimum site-wide BMPs are established in this permit to ensure all permittees are managing their sites equally to protect waters of the state from certain activities which could cause negative effects in receiving water bodies. While not all sites require a SWPPP because the SIC codes are specifically exempted in 40 CFR 122.26(b)(14), these BMPs are not specifically included for stormwater purposes. These practices are minimum requirements for all industrial sites to protect waters of the state. If the minimum BMPs are not followed, the facility may violate general criteria [10 CSR 20-7.031(4)]. Statutes are applicable to all permitted facilities in the state; therefore, pollutants cannot be released unless in accordance with RSMo 644.011 and 644.016 (17).

CHANGES IN DISCHARGES OF TOXIC POLLUTANT:
This special condition reiterates the federal rules found in 40 CFR 122.44(f) and 122.42(a)(1). In these rules, the facility is required to report changes in amounts of toxic substances discharged. Toxic substances are defined in 40 CFR 122.2 as "…any pollutant listed as toxic under section 307(a)(1) or, in the case of "sludge use or disposal practices," any pollutant identified in regulations implementing section 405(d) of the CWA." Section 307 of the CWA then refers to those parameters found in 40 CFR 401.15.

The permittee should also consider any other toxic pollutant in the discharge as reportable under this condition.

EFFLUENT LIMITATION GUIDELINE:
Effluent Limitation Guidelines, or ELGs, are found at 40 CFR 400-499. These are limitations established by the EPA based on the SIC code and the type of work a facility is conducting. Most ELGs are for process wastewater and some address stormwater. All are technology based limitations which must be met by the applicable facility at all times.

✓ The industries covered under this permit have an associated Effluent Limit Guideline (ELG) which is applicable to the stormwater discharges in this permit and is applied under 40 CFR 125.3(a).

ELECTRONIC DISCHARGE MONITORING REPORT (EDMR) SUBMISSION SYSTEM:
The U.S. Environmental Protection Agency (EPA) promulgated a final rule on October 22, 2015, to modernize CWA reporting for municipalities, industries, and other facilities by converting to an electronic data reporting system. The final rule requires regulated entities and state and federal regulators to use information technology to electronically report data required by the National Pollutant Discharge Elimination System (NPDES) permit program instead of filing paper reports. To comply with the federal rule, the Department is requiring all permittees to begin submitting discharge monitoring data and reports online.

✓ Applicable; this permit requires quarterly reports.

GENERAL CRITERIA CONSIDERATIONS:
In accordance with 40 CFR 122.44(d)(1), effluent limitations shall be placed into permits for pollutants determined to cause, have reasonable potential to cause, or to contribute to, an excursion above any water quality standard, including narrative water quality criteria. In order to comply with this regulation, the permit writer has completed a reasonable potential determination on whether discharges have reasonable potential to cause or contribute to an excursion of the general criteria listed in 10 CSR 20-7.031(4). In instances where reasonable potential exists, the permit includes limitations within the permit to address the reasonable potential. In discharges where reasonable potential does not exist, the permit may include monitoring to later determine the discharge's potential to impact the narrative criteria. Additionally, RSMo 644.076.1, as well as Standard Permit Conditions Part VIII of this permit state it shall be unlawful for any person to cause or allow any discharge of water contaminants from any water contaminant or point source located in Missouri in violation of sections 644.006 to 644.141 of the Missouri Clean Water Law or any standard, rule, or regulation promulgated by the commission.

LAND APPLICATION:
Land application, or surficial dispersion of wastewater and/or sludge, is performed by facilities to maintain a basin as no-discharge. Requirements for these types of operations are found in 10 CSR 20-6.015; authority to regulate these activities is from RSMo 644.026.

✓ Not applicable; this permit does not authorize operation of a surficial land application system to disperse wastewater or sludge.

LAND DISTURBANCE:
Land disturbance, sometimes called construction activities, are actions which cause disturbance of the root layer or soil; these include clearing, grading, and excavating of the land. 40 CFR 122.26(b)(14) and 10 CSR 20-6.200(3) requires permit coverage for these activities. Coverage is not required for facilities when only providing maintenance of original line and grade, hydraulic capacity, or to continue the original purpose of the facility.

✓ Applicable; this permit provides coverage for land disturbance activities. These activities have SWPPP requirements and may be combined with the standard site SWPPP. Land disturbance BMPs should be designed to control the expected peak discharges. The University of Missouri has design storm events for the 25 year 24 hour storm; these can be found at: http://ag3.agebb.missouri.edu/design_storm/comparison_reports/20191117_25yr_24hr_comparison_table.htm; to calculate peak discharges, the website https://www.lmnoeng.com/Hydrology/rational.php has the rational equation to calculate expected discharge volume from the peak storm events.

NUTRIENT MONITORING:
Nutrient monitoring is required for facilities characteristically or expected to discharge nutrients (nitrogenous compounds and/or phosphorus) when the design flow is equal to or greater than 0.1 MGD per 10 CSR 20-7.015(9)(D)8.

- ✓ This is a stormwater only permit; therefore, it is not subject to provisions found in 10 CSR 20-7.015 per 10 CSR 20-7.015(1)(C).

OIL/WATER SEPARATORS:
Oil water separator (OWS) tank systems are frequently found at industrial sites where process water and stormwater may contain oils and greases, oily wastewaters, or other immiscible liquids requiring separation. Food industry discharges typically require pretreatment prior to discharge to municipally owned treatment works. Per 10 CSR 26-2.010(2)(B), all oil water separator tanks must be operated according to manufacturer's specifications and authorized in NPDES permits per 10 CSR 26-2.010(2) or may be regulated as a petroleum tank.

- ✓ Not applicable; this permit does not authorize the operation of OWS. The facility must obtain a separate permit to cover operation of and discharge from these devices.

PERMIT SHIELD:
The permit shield provision of the CWA (Section 402(k)) and Missouri Clean Water Law (644.051.16 RSMo) provides that when a permit holder is in compliance with its NPDES permit or MSOP, they are effectively in compliance with certain sections of the CWA and equivalent sections of the Missouri Clean Water Law. In general, the permit shield is a legal defense against certain enforcement actions but is only available when the facility is in compliance with its permit and satisfies other specific conditions, including having completely disclosed all discharges and all facility processes and activities to the Department at time of application. It is the facility's responsibility to ensure that all potential pollutants, waste streams, discharges, and activities, as well as wastewater land application, storage, and treatment areas, are all fully disclosed to the Department at the time of application or during the draft permit review process. Subsequent requests for authorization to discharge additional pollutants or expanded or newly disclosed flows, or for authorization for previously unpermitted and undisclosed activities or discharges, will likely require permit modification or may require the facility be covered under a site specific permit.

PRETREATMENT PROGRAM:
This permit does not regulate pretreatment requirements for facilities discharging to an accepting permitted wastewater treatment facility. If applicable, the receiving entity (the publicly owned treatment works - POTW) must ensure compliance with any effluent limitation guidelines for pretreatment listed in 40 CFR Subchapter N per 10 CSR 20-6.100. Pretreatment regulations per RSMo 644.016 are limitations on the introduction of pollutants or water contaminants into publicly owned treatment works or facilities.

- ✓ Not Applicable; the facilities covered under this permit are not required to meet pretreatment requirements under an ELG.

PUBLIC NOTICE OF COVERAGE FOR AN INDIVIDUAL FACILITY:
Public Notice of reissuance of coverage is not required unless the facility is a specific type of facility as defined in 10 CSR 20-6.200(1). The need for an individual public notification process shall be determined and identified in the permit [10 CSR 20-6.020(1)(C)5.].

- ✓ Not applicable; public notice is not required for coverage under this permit to individual facilities. The MGP is public noticed in lieu of individual permit PN requirements.

REASONABLE POTENTIAL ANALYSIS (RPA):
Federal regulation 40 CFR Part 122.44(d)(1)(i) requires effluent limitations for all pollutants which are or may be discharged at a level which will cause or have the reasonable potential to cause or contribute to an in-stream excursion above narrative or numeric water quality standard. In accordance with 40 CFR Part 122.44(d)(iii) if the permit writer determines any given pollutant has the reasonable potential to cause or contribute to an in-stream excursion above the water quality standard, the permit must contain effluent limits for the pollutant.

- ✓ The permit writer reviewed industry materials, available past inspections, and other documents and research to evaluate general and narrative water quality reasonable potential for this permit. Permit writers also use the Department's permit writer's manual, the EPA's permit writer's manual (https://www.epa.gov/npdes/npdes-permit-writers-manual), program policies, and best professional judgment. For each parameter in each permit, the permit writer carefully considers all applicable information regarding technology based effluent limitations, effluent limitation guidelines, and water quality standards. Best professional judgment is based on the experience of the permit writer, cohorts in the Department and resources at the EPA, research, and maintaining continuity of permits if necessary. For stormwater permits, the permit writer is required per 10 CSR 6.200(6)(B)2 to consider: A. application and other information supplied by the permittee; B. effluent guidelines; C. best professional judgment of the permit writer; D. water quality; and E. BMPs.

SCHEDULE OF COMPLIANCE (SOC):
Per § 644.051, RSMo, a permit may be issued with a Schedule of Compliance (SOC) to provide time for a facility to come into compliance with new state or federal effluent regulations, water quality standards, or other requirements. Such a schedule is not allowed if the facility is already in compliance with the new requirement or if prohibited by other statute or regulation. An SOC includes an enforceable sequence of interim requirements (e.g. actions, operations, or milestone events) leading to compliance with the Missouri Clean Water Law, its implementing regulations, and/or the terms and conditions of an operating permit. *See also* Section 502(17) of the CWA, and 40 CFR 122.2. For new effluent limitations, the permit may include interim monitoring for the specific parameter to demonstrate the facility is not already in compliance with the new requirement. Per 40 CFR 122.47(a)(1) and 10 CSR 20-7.031(11), compliance must occur as soon as possible. If the permit provides a schedule for meeting new water quality based effluent limits, an SOC must include an enforceable, final effluent limitation in the permit even if the SOC extends beyond the life of the permit.

- ✓ Not Applicable: This permit does not contain a SOC.

SETBACKS:
Setbacks, sometimes called separation distances, are common elements of permits and are established to provide a margin of safety in order to protect the receiving water and other features from accidents, spills, unusual events, etc. Specific separation distances are included in 10 CSR 20-8 for minimum design standards of wastewater structures. While wastewater is considered separately from stormwater under this permit, the guides and Chapter 8 distances may remain relevant to requirements under this permit if deemed appropriate by the permittee.

- ✓ Discharge to the watersheds of a Metropolitan No-Discharge Stream (10 CSR 20-7.031 Table F) is authorized by this permit if the discharges are in compliance with 10 CSR 20-7.015(5) and 10 CSR 20-7.031(7). Discharges to these watersheds are authorized for uncontaminated stormwater discharges only.
- ✓ This permit authorizes stormwater discharges which are located in a way to allow water to be released into sinkholes, caves, fissures, or other openings in the ground which could drain into aquifers (except losing streams) per 10 CSR 20-7.015(7). It is the best professional judgment of the permit writer to allow discharges to losing streams as the effluent is stormwater only.
- ✓ This permit authorizes stormwater discharge in the watersheds of Outstanding state Resource Waters (OSRW); Outstanding National Resources Waters (ONRW), which includes the Ozark National Riverways and the National Wild and Scenic Rivers System; and impaired waters as designated in the 305(b) Report provided no degradation of water quality occurs in the OSRW and ONRW due to discharges from the permitted facility per 10 CSR 20-7.015(6)(B) and 10 CSR 20-7.031(3)(C). Additionally, if the facility is found to be causing degradation or contributing to an impairment by discharging a pollutant of concern during an inspection or through complaint investigations, they will be required to become a no discharge facility or obtain a site specific permit with more stringent monitoring and SWPPP requirements. Missouri's impaired waters can be found at https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters. Sites within 1000 feet of a OSRW, ONRW, or water impaired for sediment must operate as a no-discharge facility. These additional protections are borrowed from the USEPA 2021 draft Construction General Permit.

SLUDGE – DOMESTIC BIOSOLIDS:
Biosolids are solid materials resulting from domestic wastewater treatment meeting federal and state criteria for beneficial use (i.e. fertilizer). Sewage sludge is solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works; including, but not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment process; and material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screening generated during preliminary treatment of domestic sewage in a treatment works.

✓ This permit does not authorize discharge or land application of biosolids. Sludge/biosolids is not generated by this industry.

SLUDGE – INDUSTRIAL:
Industrial sludge is solid, semi-solid, or liquid residue generated during the treatment of industrial process wastewater in a treatment works; including, but not limited to, scum or solids removed in primary, secondary, or advanced wastewater treatment process; scum and solids filtered from water supplies and backwashed; and a material derived from industrial sludge.

✓ Not applicable; sludge is not generated by this industry.

SPILL REPORTING:
Any emergency involving a hazardous substance must be reported to the Department's 24 hour Environmental Emergency Response hotline at (573) 634-2436 at the earliest practicable moment after discovery. The Department may require the submittal of a written report detailing measures taken to clean up a spill. These reporting requirements apply when the spill results in chemicals or materials leaving the permitted property or reaching waters of the state. This requirement is in addition to the noncompliance reporting requirement found in Standard Conditions Part I. https://dnr.mo.gov/waste-recycling/investigations-cleanups/environmental-emergency-response.

Underground and above ground storage devices for petroleum products, vegetable oils, and animal fats may be subject to control under federal Spill Prevention, Control, and Countermeasure Regulation and are expected to be managed under those provisions, if applicable. Substances regulated by federal law under the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which are transported, stored, or used for maintenance, cleaning or repair shall be managed according to the provisions of RCRA and CERCLA.

STORMWATER POLLUTION PREVENTION PLAN (SWPPP):
In accordance with 40 CFR 122.44(k), BMPs must be used to control or abate the discharge of pollutants when: 1) Authorized under section 304(e) of the CWA for the control of toxic pollutants and hazardous substances from ancillary industrial activities; 2) Authorized under section 402(p) of the CWA for the control of stormwater discharges; 3) Numeric effluent limitations are infeasible; or 4) the practices are reasonably necessary to achieve effluent limitations and standards or to carry out the purposes and intent of the CWA. In accordance with the EPA's *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites,* (Document number EPA 833-R-06-004) published by the EPA in 2007 https://www.epa.gov/sites/production/files/2015-10/documents/sw_swppp_guide.pdf, BMPs are measures or practices used to reduce the amount of pollution entering waters of the state from a permitted facility. BMPs may take the form of a process, activity, or physical structure. Additionally, in accordance with the Stormwater Management, a SWPPP is a series of steps and activities to 1) identify sources of pollution or contamination, and 2) select and carry out actions which prevent or control the pollution of storm water discharges. Additional information can be found in *Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices* (EPA 832-R-92-006; September 1992).

A SWPPP must be prepared if the SIC code for the facility is found in 40 CFR 122.26(b)(14) and/or 10 CSR 20-6.200(2). A SWPPP may be required of other facilities where stormwater has been identified as necessitating better management.

The purpose of a SWPPP is to comply with all applicable stormwater regulations by creating an adaptive management plan to control and mitigate stream pollution from stormwater runoff. Developing a SWPPP provides opportunities to employ appropriate BMPs to minimize the risk of pollutants being discharged during storm events. The following paragraph outlines the general steps the permittee should take to determine which BMPs will work to achieve the benchmark values or limits in the permit. This section is not intended to be all encompassing or restrict the use of any physical BMP or operational and maintenance procedure assisting in pollution control. Additional steps or revisions to the SWPPP may be required to meet the requirements of the permit.

Areas which should be included in the SWPPP are identified in 40 CFR 122.26(b)(14). Once the potential sources of stormwater pollution have been identified, a plan should be formulated to best control the amount of pollutant being released and discharged by each activity or source. This should include, but is not limited to, minimizing exposure to stormwater, good housekeeping measures, proper facility and equipment maintenance, spill prevention and response, vehicle traffic control, and proper materials handling. Once a plan has been developed, the facility will employ the control measures determined to be adequate to prevent pollution from entering waters of the state. The facility will conduct inspections of the BMPs to ensure they are working properly and re-evaluate any BMP not achieving compliance with permitting requirements. For example if the BMP being employed is deficient in controlling stormwater pollution, corrective action should be taken to repair, improve, or replace the failing BMP. If failures do occur, continue this trial and error process until appropriate BMPs have been established.

The EPA has developed factsheets on the pollutants of concern for specific industries along with the BMPs to control and minimize stormwater (https://www.epa.gov/npdes/stormwater-discharges-industrial-activities). Along with EPA's factsheets, the International Stormwater BMP database (https://bmpdatabase.org/) may provide guidance on BMPs appropriate for specific industries.

For new, altered, or expanded stormwater discharges, the SWPPP shall identify reasonable and effective BMPs while accounting for environmental impacts of varying control methods. The antidegradation analysis must document why no discharge or no exposure options are not feasible. The selection and documentation of appropriate control measures shall serve as an alternative analysis of technology and fulfill the requirements of antidegradation [10 CSR 20-7.031(3)].

Alternative analysis evaluation of the BMPs is a structured evaluation of BMPs which are reasonable and cost effective. The alternative analysis evaluation should include practices designed to be: 1) non-degrading; 2) less degrading; or 3) degrading water quality. The glossary of the *Antidegradation Implementation Procedure* defines these three terms. The chosen BMP will be the most reasonable and effective management strategy while ensuring the highest statutory and regulatory requirements are achieved and the highest quality water attainable for the facility is discharged. The alternative analysis evaluation must demonstrate why "no discharge" or "no exposure" is not a feasible alternative at the facility. This structured analysis of BMPs serves as the antidegradation review, fulfilling the requirements of 10 CSR 20-7.031(3) Water Quality Standards and *Antidegradation Implementation Procedure*, Section II.B.

- ✓ Applicable: A SWPPP shall be developed and implemented for each site and shall incorporate required practices identified by the Department with jurisdiction, incorporate control practices specific to site conditions, and provide for maintenance and adherence to the plan.

UNDERGROUND INJECTION CONTROL (UIC):
The UIC program for all classes of wells in the State of Missouri is administered by the Missouri Department of Natural Resources and approved by EPA pursuant to section 1422 and 1425 of the Safe Drinking Water Act (SDWA) and 40 CFR 147 Subpart AA. Injection wells are classified based on the liquids which are being injected. Class I wells are hazardous waste wells which are banned by RSMo 577.155; Class II wells are established for oil and natural gas production; Class III wells are used to inject fluids to extract minerals; Class IV wells are also banned by Missouri in RSMo 577.155; Class V wells are shallow injection wells; some examples are heat pump wells and groundwater remediation wells. Domestic wastewater being disposed of sub-surface is also considered a Class V well.

In accordance with 40 CFR 144.82, construction, operation, maintenance, conversion, plugging, or closure of injection wells shall not cause movement of fluids containing any contaminant into Underground Sources of Drinking Water (USDW) if the presence of any contaminant may cause a violation of drinking water standards or groundwater standards under 10 CSR 20-7.031 or other health-based standards or may otherwise adversely affect human health. If the Department finds the injection activity may endanger USDWs, the Department may require closure of the injection wells or other actions listed in 40 CFR 144.12(c), (d), or (e). In accordance with 40 CFR 144.26, the permittee shall submit a Class V Well Inventory Form for each active or new underground injection well drilled, or when the status of a well changes, to the Missouri Department of Natural Resources, Geological Survey Program, P.O. Box 250, Rolla, Missouri 65402. Single family residential septic systems and non-residential septic systems used solely for sanitary waste and having the capacity to serve fewer than 20 persons a day are excluded from the UIC requirements (40 CFR 144.81(9)).

- ✓ Not applicable; this permit does not authorize subsurface wastewater systems or other underground injection. These activities must be assessed under an application for a site specific permit. Certain discharges of stormwater into sinkholes may qualify as UIC. It is important the permittee evaluate all stormwater basins, even those holding water; as sinkholes have varying seepage rates. This permit does not allow stormwater discharges into sinkholes. The facility must ensure sinkholes are avoided in the construction process. The State's online mapping resource https://modnr.maps.arcgis.com/apps/webappviewer/index.html?id=87ebef4af15d438ca658ce0b2bbc862e has a sinkhole layer.

VARIANCE:
Per the Missouri Clean Water Law Section 644.061.4, variances shall be granted for such period of time and under such terms and conditions as shall be specified by the commission in its order. The variance may be extended by affirmative action of the commission. In no event shall the variance be granted for a period of time greater than is reasonably necessary for complying with the Missouri Clean Water Law Section 644.006 to 644.141 or any standard, rule, or regulation promulgated pursuant to Missouri Clean Water Law Section 644.006 to 644.141.

- ✓ Not Applicable: This permit is not drafted under premises of a petition for variance.

WASTELOAD ALLOCATIONS (WLA) FOR LIMITATIONS:
Per 10 CSR 20-2.010(78), the amount of pollutant each discharger is allowed by the Department to release into a given stream after the Department has determined total amount of pollutant which may be discharged into the stream without endangering its water quality. Water quality based maximum daily and average monthly effluent limitations were calculated using methods and procedures outlined in USEPA's Technical Support Document For Water Quality-based Toxics Control (TSD) (EPA/505/2-90-001).

- ✓ Not applicable; water quality limitations were not applied in this permit.

WATER QUALITY STANDARDS:
Per 10 CSR 20-7.031(4), General Criteria shall be applicable to all waters of the state at all times, including mixing zones. Additionally, 40 CFR 122.44(d)(1) directs the Department to include in each NPDES permit conditions to achieve water quality established under Section 303 of the CWA, including state narrative criteria for water quality.

WHOLE EFFLUENT TOXICITY (WET) TEST:
Per 10 CSR 20-7.031(1)(FF), a toxicity test conducted under specified laboratory conditions on specific indicator organism; and per 40 CFR 122.2, the aggregate toxic effect of an effluent measured directly by a toxicity test. A WET test is a quantifiable method of determining if a discharge from a facility may be causing toxicity to aquatic life by itself, in combination with, or through synergistic responses when mixed with receiving water.

- ✓ Not applicable: At this time, permittees are not required to conduct a WET test. This permit is for stormwater only.

PART IV – EFFLUENT LIMITATIONS DETERMINATION

EPA Construction General Permit (CGP)
The CGP was used to research and support best professional judgment decisions made in establishing technology-based conditions for this general permit which are consistent with national standards. The permit writer determined the standards established by the CGP are achievable and consistent with federal regulations. Additionally, the conditions reflecting the best practicable technology currently available are utilized to implement the ELG.

In this general permit, technology-based effluent conditions are established through the SWPPP and BMP requirements. Effective BMPs should be designed on a site-specific basis. The implementation of inspections provides a tool for each facility to evaluate the effectiveness of BMPs to ensure protection of water quality. Any flow through an outfall is considered a discharge. Future permit action due to permit modification may contain new operating permit terms and conditions which supersede the terms and conditions, including effluent limitations, of this operating permit.

PART V–REPORTING REQUIREMENTS

SAMPLING:
The permittee is not required to sample stormwater under this permit. The Department may require sampling and reporting as a result of illegal discharges, compliance issues related to water quality concerns or BMP effectiveness, or evidence of off-site impacts from activities at the facility. If such an action is needed, the Department will specify in writing the sampling requirements, including such information as location and extent. If the permittee refuses to perform sampling when required, the Department may terminate the general permit and require the facility to obtain a site-specific permit with sampling requirements.

REPORTING:
There are quarterly reporting requirements for MO-R100xxx land disturbance permits. Project specific information is required to be report to the Department through the eDMR system.

PART VI – RAINFALL VALUES FOR MISSOURI & SURFACE WATER BUFFER ZONES

Knowledge of the 2-year, 24-hour storm event is used in this permit for two main reasons:
1) The design, installation, and maintenance of effective erosion and sediment controls to minimize the discharge of pollutants.
2) If the seven-day inspection frequency is utilized, an inspection must occur within 48 hours after any storm event equal to or greater than a 2-year, 24 hour storm has ceased.
For site-specific 2-year, 24-hour storm event information utilize the National Oceanic and Atmospheric Administration's National Weather Service Atlas 14 (NOAA Atlas 14) which is located at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html. For more information visit; https://www.weather.gov/media/owp/oh/hdsc/docs/Atlas14_Volume8.pdf.

Surface Water Buffer Zones: In order to design controls that match the sediment removal efficiency of a 50-foot buffer, you first need to know what this efficiency is for your site. The sediment removal efficiencies of natural buffers vary according to a number of site-specific factors, including precipitation, soil type, land cover, slope length, width, steepness, and the types of erosion and sediment controls used to reduce the discharge of sediment prior to the buffer. For additional information; https://www.epa.gov/sites/default/files/2017-02/documents/2017_cgp_final_appendix_g_-_buffer_reqs_508.pdf

PART VII – ADMINISTRATIVE REQUIREMENTS

On the basis of preliminary staff review and applicable standards and regulations, the Department, as administrative agent for the Missouri Clean Water Commission, proposes to issue a permit(s) subject to certain effluent limitations, schedules, and special conditions contained herein and within the permit. The proposed determinations are tentative pending public comment.

PUBLIC MEETING:
The department hosted three public meetings for this permit. The meetings were held on January 27, February 17, and March 9, 2021.

PUBLIC NOTICE:
The Department shall give public notice when a draft permit has been prepared and its issuance is pending. Additionally, public notice will be issued if a public hearing is to be held because of a significant degree of interest or because of water quality concerns related to a draft permit. No public notice is required when a request for a permit modification or termination is denied; however, the requester and facility must be notified of the denial in writing.

The Department must give public notice of a pending permit or of a new or reissued Missouri State Operating Permit. The public comment period is a length of time not less than thirty (30) days following the date of the public notice, during which interested persons may submit written comments about the proposed permit.

For persons wanting to submit comments regarding this proposed permit, please refer to the Public Notice page located at the front of this draft permit. The Public Notice page gives direction on how and where to submit appropriate comments.

- ✓ The Public Notice period for this permit is started March 25, 2022 and ended April 25, 2022. Two comment letters were received.

DATE OF FACT SHEET: 03/2/2022

COMPLETED BY:
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