Fort Dupont Ice Arena

Washington, DC

BID SET

SPECIFICATIONS – VOLUME 2

15 DECEMBER 2017

SINKCOMBSDETHLEFS
SPORTS ARCHITECTURE

QUINN EVANS
ARCHITECTS

VOLUME II

DIVISION 21 – FIRE SUPPRESSION

DIVISION 22- PLUMBING

DIVISION 23– HEATING, VENTILATING, AND AIR CONDITIONING

DIVISION 27 – COMMUNICATIONS

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

DIVISION 31 - EARTHWORK

DIVISION 32 – EXTERIOR IMPROVEMENTS

DIVISION 33 - UTILITIES

END OF VOLUME 2

SECTION 21 1313

FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Fire department connections.
4. Backflow preventer.
5. Sprinklers.
6. Alarm devices.
7. Pressure gages.

B. Related Sections:
1. Division 01 in its entirety
2. Section 283111, “Digital Addressable Fire Alarm System”

1.3 DEFINITIONS

A. AHJ: Authorities Having Jurisdiction.

B. Engineer: JVP Engineers, P.C.

C. FM: Factory Mutual.

D. FM Approved: Materials or equipment approved by Factory Mutual and included in the most recent edition of the FM Approval Guide.

E. Furnish: Supply materials.

F. GPM: Gallons per minute.

G. Install: Install materials, mount and connect equipment or assemblies.

H. Provide: Furnish, install and connect.

I. PSI: Pounds per square inch.

J. NICET: National Institute for Certification in Engineering Technologies.

K. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

L. UL: Underwriters Laboratories, Inc.

M. UL Listed: Materials or equipment listed by Underwriters Laboratories and included in the most recent edition of the UL Fire Protection Equipment Directory.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.
1. Wet-pipe sprinkler protection shall be provided throughout the entire building, unless noted otherwise.

B. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing pressurized air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from sprinklers that are open.
1. Dry-pipe sprinkler protection shall be provided in areas/spaces subject to temperatures below 40°F.

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

B. High-Pressure Piping System Component: Listed for 300-psig minimum working pressure.

C. The guidelines are not intended to be all-inclusive and do not limit or define the Contractor's Scope of Work. The work includes the following:
1. Provide a combination sprinkler/standpipe system including but not limited to: piping and risers, sprinklers, control valves, drain and test valves, hose valve outlets, hangers and supports, sleeves, signage, spare parts and cabinet, fire department connections, fire pump test header, backflow preventer, and all associated labor for installation.
2. Provide pressure reducing valves and high-pressure fittings for all system components subject to normal operating pressure greater than 175 psi.
3. Provide design submissions to the Engineer and AHJ for review, including drawings showing system coverage, hydrant flow test information, and other required elements for compliance with NFPA and all applicable codes.
4. Coordinate core drilling and firestopping with the general contractor to meet project requirements.
5. Provide coordination of the work with other trades.
6. Provide on-site project supervision.
7. Provide permits, fees, and other charges required for the work.
8. Prepare record documents, operating and maintenance instructions, and training of Owner's personnel.
9. Perform system acceptance testing.
10. Provide warranty of equipment and labor.

D. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a registered fire protection engineer or a minimum NICET Level III technician. Engineering analysis shall be based on a fire-hydrant water flow test (provided by contractor) dated not more than 1 year from the date of shop drawing submission.

E. Sprinkler Systems:
1. Sprinkler system design shall be approved by the Engineer and AHJ.

2. Design shall be based upon the contract drawings and all sections within these specifications.
3. Margin of Safety for Available Water Flow and Pressure: 10 percent minimum, including losses through water-service piping, valves, strainers, and backflow preventers at the connection to the water supply.
4. Sprinkler Occupancy Hazard Classifications:
   a. Electrical Equipment Rooms: Ordinary Hazard, Group 1
   b. Parking areas: Ordinary Hazard, Group 1
   c. General Storage Areas: Ordinary Hazard, Group 2
   d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1
   e. Office, Locker Rooms, Public Areas, Ice Rack: Light Hazard
   f.
5. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
   d. Design areas for dry-pipe sprinkler systems shall increased by 30 percent without reduction to design density.
   e. Sprinkler design area reduction per NFPA 13 shall be permitted.
6. Maximum Protection Area per Sprinkler: Per UL listing or NFPA 13 criteria below:
   a. Light Hazard: 225 sq. ft. maximum.
   b. Ordinary Hazard: 130 sq. ft.
   c. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
7. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm.
   b. Ordinary-Hazard Occupancies: 250 gpm.
8. Residual pressure at each hose-connection outlet shall be as follows:
   a. Min: NPS 2–½ Hose Connections: 100 psi.
   b. Max: NPS 2–½ Hose Connections: 175 psi.

1.6 SUBMITTALS

A. General Submittal Requirements:
   1. Submittals shall be submitted and approved by the AHJ and Engineer. Shop drawings and submitted data shall first be reviewed and approved by the Engineer of record.
   2. Refer to Division 1 for basic information relating to submittal requirements. Partial submittals will not be acceptable and will be returned without review. Before any work is commenced, the submittal must be approved by the Engineers and AHJ.

B. Product Data: Provide manufacturers product data sheets for each material proposed to be installed as part of the fire suppression system. The data sheets shall be compiled in a three-ring binder with the model of each material highlighted on the data sheet.

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

D. System Supplier and Installer Requirements: Shop drawing design shall be by a NICET Level III or IV Automatic Sprinkler Systems Technician or a Registered Fire Protection Engineer. System distributor and electrical contractor shall have offices, which have been in existence for at least 3-years, within a 50-mile radius of the Project Site. Installation shall be accomplished by a contractor with a minimum of 5-years experience in the installation of automatic sprinkler and standpipe systems. The owner may reject any proposed installer who cannot show evidence of such qualifications. The services of a technician provided by the control equipment manufacturer shall be provided to supervise installation, adjustments, and tests of the system.

E. Coordination Drawings:
   1. Refer to Section 019113 "Commissioning Requirements" for additional submittal requirements that apply to the work of this Section.
   2. System shall be design with 3-D modeling software consistent with the project requirements.
   3. Sprinkler system, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved.
      a. Domestic water piping.
      b. HVAC systems.
      c. Electrical systems.

F. Qualification Data: Shop installation drawings and system installation shall be supervised by a NICET Level III or IV Certified Automatic Sprinkler System Technician.

G. Approved Sprinkler and Standpipe Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by the Architect/Engineer and by authorities having jurisdiction, including hydraulic calculations.

H. Welding certificates.

I. Fire hydrant flow test report, dated within one year of the final shop drawing submittal.

J. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and “Contractor’s Material and Test Certificate for Underground Piping”.

K. Field quality-control reports.

L. Operation and Maintenance Data: For sprinkler and standpipe specialties to include in emergency, operation, and maintenance manuals.

1.7 OPERATION AND MAINTENANCE MANUALS

A. General: Provide operation and maintenance manuals not less than 30-days prior to the final acceptance testing of the entire system and after the preliminary testing has been completed. The manuals shall be used during the instruction period hereinafter specified. Provide six (6) bound copies of an Operation and Maintenance Manual. The manual shall include an index, copies of all approved shop drawings and submittal materials, and a complete parts list of all components. The manual shall also include, for each item, the manufacturer's name, the serial number of the part, an ordering number, if appropriate, and a physical description of the part. Following the acceptance test, drawings and submittal materials shall be updated as necessary to reflect as built conditions.

1.8 ASBUILT DRAWINGS

A. General: Prepare and submit to the engineer six (6) sets of detailed "AsBuilt Drawings”. The drawings shall be prepared on uniform sized sheets not less than 30-inches by 42-inches. These drawings shall be submitted within 2-weeks after the final acceptance test of the system. The drawings shall show the system as installed, including all deviations from both the project drawings and the approved shop drawings. The drawings shall include the following information:
   1. The exact locations and installation details of the installed equipment.

B. Record Drawing Software: Provide two (2) CD containing AutoCAD Release 2007 based record drawings of all as built drawings and schematics.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
      a. Engineering Responsibility: Preparation of working plans, calculations, and record of completion shall be prepared by a registered professional engineer, or NICET Level IV minimum.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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

1.10 COORDINATION

A. Coordinate layout and installation of fire suppression equipment with other construction trades.

1.11 EXTRA MATERIALS

A. Furnish extra materials (as identified below) that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Sprinklers and Cabinets: Provide finished, wall-mounted, steel cabinet(s) with hinged cover, and with space for minimum of twelve spare sprinklers plus sprinkler wrench per cabinet. Include sprinklers and wrenches for each type installed in the amount required by NFPA 13. Include additional cabinets with sprinklers and wrenches as required.

1.12 WARRANTY

A. The Contractor shall warranty labor, materials and equipment provided under this contract against system defects for a period of two (2) years after the date of final acceptance of this work by the Owner.

B. Service during the warranty period shall be provided by the contractor seven (7) days a week including holidays. All repairs shall be performed within eight (8) hours after notification.

C. Should the Contractor fail to comply with the above requirements, the Owner will then have the option to make the necessary repairs and back charge the Contractor without any loss of warranty or guarantee as provided by the contract.

D. Any warranty which is in conflict with the above will not be acceptable.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Steel pipe shall be new, designed for 175 psi working pressure, conforming to ASTM specifications, and have the manufacturer's name and brand along with the applicable ASTM

standard marked on each length of pipe. Piping in high-pressure zone areas shall be designed for 300 psi working pressure.

B. CPVC piping shall not be used.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 40 (Standard Weight), Black-Steel Pipe: ASTM A 53/A 53M. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M. Pipe ends may be factory or field formed to match joining method.

C. Only schedule 40 piping shall be permitted to be threaded or cut grooved. Piping with wall thickness less than schedule 10 shall not be used.

D. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

E. Steel Couplings: ASTM A 865.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Cast-Iron Flanges: ASME 16.1, Class 125.

H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

J. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Anvil International, Inc.
      b. Corcoran Piping System Co.
      c. National Fittings, Inc.
      d. Shurjoint Piping Products.
      e. Tyco Fire & Building Products LP.
      f. Victaulic Company.
   2. Pressure Rating**:** 175 psig minimum.
   3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

K. Push-on, plain-end or fitting that “mechanically bite” into the pipe shall not be used on above ground systems.

L. Mechanical-T and –cross fittings shall only be used to accommodate a design change for installed pipes. They are not permitted as the basis of new system design/installation.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
   1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
   2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

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

2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:
   1. Valves shall be UL listed or FM approved.
   2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psi.

B. Check Valves:
   1. Manufacturers: Subject to compliance with requirements.
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
      a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
      b. Anvil International, Inc.
      c. Clow Valve Company; a division of McWane, Inc.
      d. Crane Co.; Crane Valve Group; Crane Valves.
      e. Fire-End & Croker Corporation.
      f. Fire Protection Products, Inc.
      g. Globe Fire Sprinkler Corporation.
      h. Groeniger & Company.
      i. Kennedy Valve; a division of McWane, Inc.
      j. Matco-Norca.
      k. Metraflex, Inc.
      l. Milwaukee Valve Company.
      m. Mueller Co.; Water Products Division.
      n. NIBCO INC.
      o. Potter Roemer.
      p. Reliable Automatic Sprinkler Co., Inc.
      q. Shurjoint Piping Products.
      r. Tyco Fire & Building Products LP.
      s. United Brass Works, Inc.
      t. Venus Fire Protection Ltd.
      u. Victaulic Company.
      v. Viking Corporation.
      w. Watts Water Technologies, Inc.
   3. Standard: UL 312.
   4. Pressure Rating: 250 psi minimum.
   5. Type: Swing check or wafer-type.
   6. Body Material: Cast iron.
   7. End Connections: Flanged or grooved.

C. Iron OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements.
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
   a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
   b. American Valve, Inc.
   c. Clow Valve Company; a division of McWane, Inc.
   d. Crane Co.; Crane Valve Group; Crane Valves.
   e. Crane Co.; Crane Valve Group; Jenkins Valves.
   f. Crane Co.; Crane Valve Group; Stockham Division.
   g. Hammond Valve.
   h. Milwaukee Valve Company.
   i. Mueller Co.; Water Products Division.
   j. NIBCO INC.
   k. Shurjoint Piping Products.
   l. Tyco Fire & Building Products LP.
   m. United Brass Works, Inc.
   n. Watts Water Technologies, Inc.
3. Standard: UL 262.
4. Pressure Rating: 250 psi minimum.
5. Body Material: Cast or ductile iron.
6. End Connections: Flanged or grooved.

D. Indicating-Type Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements.
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
   a. Anvil International, Inc.
   b. Global Safety Products, Inc.
   c. Kennedy Valve; a division of McWane, Inc.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Shurjoint Piping Products.
   g. Tyco Fire & Building Products LP.
   h. Victaulic Company.
3. Standard: UL 1091.
4. Pressure Rating: 175 psig minimum.
5. Valves shall incorporate integral tamper switches.
6. Valves NPS 2 (DN 50) and Smaller:
   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.
7. Valves NPS 2-1/2 (DN 65) and Larger:
   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged or grooved.
8. Valve Operation: Integral visual indicating device.
9. Butterfly valves installed on fire pump test connections shall be specifically listed for installation in the normally closed position.

2.5 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 psig minimum.

B. Ball Valves:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Anvil International, Inc.
   b. Barnett.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Fire-End & Croker Corporation.
   e. Fire Protection Products, Inc.
   f. Flowserve.
   g. FNW.
   h. Jomar International, Ltd.
   i. Kennedy Valve; a division of McWane, Inc.
   j. Kitz Corporation.
   k. Legend Valve.
   l. Metso Automation USA Inc.
   m. Milwaukee Valve Company.
   n. NIBCO INC.
   o. Potter Roemer.
   p. Red-White Valve Corporation.
   q. Southern Manufacturing Group.
   r. Stewart, M. A. and Sons Ltd.
   s. Tyco Fire & Building Products LP.
   t. Victaulic Company.
   u. Watts Water Technologies, Inc.

C. Globe Valves:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Fire Protection Products, Inc.
   b. United Brass Works, Inc.

2.6 SPECIALTY VALVES

A. General Requirements:
1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 psi minimum.
3. Body Material: Cast or ductile iron
4. Size Same as connected piping
5. End Connections: Flanged or grooved.

B. Dry-Pipe Valves:
1. Manufacturers: Subject to compliance with requirements.
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
   a. Tyco Fire & Building Products LP.
   b. Victaulic Company.
   c. Viking Corporation.

3. Standard: UL 260
4. Design: Differential-pressure type.
5. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
6. Air-Pressure Maintenance Device:
    a. Manufacturers: Subject to compliance with requirements.
    b. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
        1) Tyco Fire & Building Products LP.
        2) Victaulic Company.
        3) Viking Corporation.
    c. Standard: UL 260.
    d. Type: Automatic device to maintain minimum air pressure in piping.
    e. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psi adjustable range, and 175-psig outlet pressure.
7. Air Compressor:
    a. Manufacturers: Subject to compliance with requirements.
    b. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
        1) Gast Manufacturing Inc.
        2) General Air Products, Inc,
        3) Viking Corporation.
    c. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
    d. Motor Horsepower: Fractional.
    e. Power: 120-V ac, 60 Hz, single phase.

C. Automatic (Ball Drip) Drain Valves:
1. Manufacturers: Subject to compliance with requirements.
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
    a. Reliable Automatic Sprinkler Co., Inc.
    b. Tyco Fire & Building Products LP.
3. Standard: UL 1726.
4. Pressure Rating: 175 psi minimum.
5. Type: Automatic draining, ball check.
6. Size: NPS 3/4 (DN 20).
7. End Connections: Threaded.

2.7 FIRE-DEPARTMENT CONNECTIONS

A. Fire department connections shall conform to the following:
1. Manufacturers: **Potter Roemer Model 5801-5836 or approved equal.**
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the drawings or comparable product by one of the following:
    a. Elkhart Brass Mfg. Company, Inc.
    b. GMR International Equipment Corporation.
    c. Guardian Fire Equipment, Inc.
    d. Potter Roemer.
3. Standard: UL 405.
4. Type: Flush, for wall mounting.

5. Pressure Rating: 175 psi minimum.
6. Body Material: Corrosion-resistant metal.
7. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
8. Caps: Brass, lugged type, with gasket and chain.
9. Escutcheon Plate: Rectangular, brass, wall type.
10. Outlet: With pipe threads.
11. Body Style: Horizontal.
12. Number of Inlets: Three.
13. Escutcheon Plate Marking: Similar to "AUTO SPKR".
14. Finish: Polished chrome plated.
15. Outlet Size: NPS 6

2.8 BACKFLOW PREVENTER

A. Reduced Pressure Zone Backflow-Prevention Assemblies:
1. Basis-of-Design Product: Subject to compliance with requirements, provide an Ames Fire & Waterworks Model 4000SS Reduced Pressure Zone Backflow Preventer (or approved equivalent) at the location indicated on the drawings.
2. Operation: Continuous-pressure applications, unless otherwise indicated.
3. Size: 6 inches.
4. Design Flow Rate: **750** gpm
5. Pressure Loss at Design Flow Rate: 9 psi.
6. End Connections: Flanged.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: Supervised outside screw and yoke gate-type with flanged ends on inlet and outlet.

2.9 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Anvil International, Inc.
   b. National Fittings, Inc.
   c. Shurjoint Piping Products.
   d. Tyco Fire & Building Products LP.
   e. Victaulic Company.
2. Standard: UL 213.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved or threaded.
9. Mechanical-T and –cross fittings shall only be used to accommodate a design change for installed pipes. They are not permitted as the basis of new system design/installation.

B. Inspectors Test and Drain Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. AGF Manufacturing Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Grooved or threaded.
7. Test Orifice Size: Smallest orifice of zone served.

2.10 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Reliable Automatic Sprinkler Co., Inc.
   2. Tyco Fire & Building Products LP.
   3. Victaulic Company.
   4. Viking Corporation.

B. General Requirements:
   1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
   3. All sprinklers shall be of quick response type.

C. Automatic Sprinklers with Heat-Responsive Element:
   1. Characteristics: Unless noted otherwise quick response, nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application. Sprinklers within mechanical, electrical, telephone, or similar rooms shall be of “intermediate” temperature classification.

D. Sprinkler Types and Finishes:
   1. Common Corridors: Concealed sidewall-type sprinkler with ~~dome~~**flush** coverplate. Finished in white.
   2. Dwelling Unit (Areas with Ceilings): Concealed pendent-type sprinkler with flush coverplate. Finished in white.
   3. Dwelling Unit (Areas without Ceilings): Concealed sidewall-type sprinkler with ~~domed~~**flush** coverplate. Finished in white.
   4. Typical Areas with Ceilings: Concealed pendent-type sprinkler with flush coverplate. Finished in white.
   5. Typical Areas without Ceilings: Upright-type sprinkler with ~~chrome~~**brass** finish.

E. Sprinkler Guards:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Reliable Automatic Sprinkler Co., Inc.
      b. Tyco Fire & Building Products LP.

c. Victaulic Company.
d. Viking Corporation.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.11 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Flow Indicators:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. ADT Security Services, Inc.
b. McDonnell & Miller; ITT Industries.
c. Potter Electric Signal Company.
d. Viking Corporation.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false.
5. Type: Paddle operated.
6. Pressure Rating: 250 psi.
7. Design Installation: Horizontal or vertical.

C. Pressure Switches:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Barksdale, Inc.
b. Detroit Switch, Inc.
c. Potter Electric Signal Company.
d. Tyco Fire & Building Products LP.
e. United Electric Controls Co.
f. Viking Corporation.
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

D. Valve Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Fire-Lite Alarms, Inc.; a Honeywell company.
b. Kennedy Valve; a division of McWane, Inc.
c. Potter Electric Signal Company.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position, or closed for pump test connection and roof manifold.

2.12 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. AMETEK; U.S. Gauge Division.
   2. Ashcroft, Inc.
   3. Brecco Corporation.
   4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 psig minimum.

E. Water and Air System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

2.13 SLEEVES

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

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire hydrant flow test according to NFPA 13, NFPA 25, and NFPA 291. Use results of flow test for system design calculations required in "Quality Assurance" Article above. Flow test shall be performed not more than 1 year from date of shop drawing submission.

3.2 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler feed main piping to fire pump discharge outlet. Install fire pump bypass piping. Connect fire pump intake outlet to backflow preventer.

B. Install backflow preventer, strainer, pressure gauges, drain, and other accessories indicated at connection to incoming water-service piping stub-out (to be provided by the underground utility contractor).

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Contractor shall be responsible for coordinating sprinkler piping installation with structural members, HVAC ducting and equipment, plumbing piping, and all other building components.
   1. Deviations from design drawings require written approval from the Engineer. This does not include revisions to the pipe locations for the purpose of coordination.

B. All sprinkler piping shall be concealed in finished ceiling areas and installed a minimum of 12 inches above suspended ceilings**, where possible**.

C. Where exposed, all piping shall be installed as high as possible and painted to match the above ceiling.

D. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

E. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

F. Install "Inspector's Test Connections" off the main sprinkler/standpipe risers, complete with shutoff valve, and sized and located according to NFPA 13.

G. Install sprinkler piping with additional auxiliary hose bibs and drains for complete system drainage.

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes as indicated on the drawings.

I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to spill to outside building.

J. Install drain piping to discharge to the exterior of the building. All exterior drain discharge outlets shall be properly placed to prevent the following:
   1. Water damage to the exterior of the building, walkways, and surrounding landscape.
   2. Impediments to pedestrian travel.
   3. Water ponding.

K. Install fire alarm devices (water flow, tamper switches) in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gages at the building fire pump, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

N. Sprinkler piping shall not be installed directly above any electrical equipment or panels.

O. Connect compressed air supply to dry pipe sprinkler system piping.

P. Install all piping to dry pipe systems with water supply from heated space.

Q. Drain, pressurize (with air), and check dry pipe and preaction sprinkler system piping.

R. Install drum drip drains for each dry pipe sprinkler system.

S. Provide inspectors test connection as required for each dry pipe and preaction sprinkler system. Inspectors test connections shall be installed at the most remote point of the system and be hard piped back to the express drain.

T. Provide wall-mounted signage above each FDC indicating that FDC’s are interconnected. Signage shall be approved by the local fire department.

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

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

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

D. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

G. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

H. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

J. Plain-end couplings or other fittings that mechanically “bite” into piping are not permitted.

K. Rigid grooved couplings shall be used all vertical pipe runs.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and AHJ.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install a backflow preventer as indicated on the drawings. Sprinklers shall be symmetrically installed to align with other sprinklers in the same area/room.

3.6 SPRINKLER INSTALLATION

A. Where sprinklers are installed on ceiling tiles, sprinklers shall be installed in the center of the tile. Install all sprinklers in 2'x2' ACT panels in the center of the panels.

B. Where installed in gypsum ceilings, sprinklers shall be installed in alignment with lighting fixtures and other architectural elements, where necessary.

3.7 HANGERS AND SUPPORTS

A. General:
1. Install all hangers in accordance with NFPA 13.
2. All piping must be substantially supported from building structure and only approved types of hangers shall be used. Piping lines under ducts shall not be supported from duct work, but shall be supported from building structure with trapeze hangers where necessary or from steel angles supporting duct work in accordance with NFPA 13.
3. Thread rods shall not be bent.
4. Hanger components shall be ferrous.
5. Attach hanger to top chord of bar joists only.
6. Powder driven studs shall not be used.

B. Feed and Cross Mains: Install at least one hanger per length of pipe up to 8-feet in length joined by grooved couplings.

C. Risers
1. Risers shall be supported at the lowest level and alternate levels above using riser clamp

3.8 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire-department connections as indicated on the drawings.

B. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

3.9 ESCUTCHEON INSTALLATION

A. Install escutcheons for exposed penetrations of walls and ceilings.

B. Escutcheons for New Piping:
1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, stamped steel with set-screw or spring clips.
3. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.10 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes passing through penetrations in concrete and/or masonry floors, partitions, roofs, and walls, except where 1” clearance is provided around the perimeter of the penetrating pipe.

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

C. Install sleeves in new partitions, slabs, and walls as they are built.

D. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 7 Section "Joint Sealants."

E. Seal space outside of sleeves in concrete slabs and walls with grout.

F. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

G. Install sleeve materials according to the following applications:
   1. Sleeves for Piping Passing through Concrete Floor Slabs: Galvanized-steel pipe.
      a. Extend sleeves 2 inches above finished floor level.
      b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
   2. Sleeves for Piping Passing through Interior Concrete and Masonry Walls:
      a. Galvanized-steel-pipe sleeves

H. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.11 IDENTIFICATION AND PAINTING

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

B. Identify system components, wiring, cabling and terminals. Comply with requirements for identification specified in Division 16 Section "Electrical Identification."

C. All exposed piping in back-of-house spaces such as mechanical, storage and electrical rooms shall be painted red.

D. All exposed piping in common areas and public spaces shall be painted to match the architectural finishes (i.e. stairs). Comply with requirements for painting specified in Division 9 Section, “Painting.”

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Leak Test: After installation, charge systems with water to 200 psi or 50 psi above system working pressure (whichever is greater) for a period of 2 hours and test for leaks. Repair leaks and retest until no leaks exist.
   2. Leak Test (dry and preaction systems): In addition to the leak test indicated above, charge systems to 40 psi with air for a period of 24 hours and test for leaks. The maximum acceptable leakage is 1.5 psi per 24-hour period. Where the system does not comply with these requirements, repair leaks and retest until no leaks exist.
   3. Trip Test (dry and preaction systems): In addition to the leak tests indicated above, a trip test shall be performed to ensure that water reaches the most remote sprinkler within 60 seconds of air pressure loss (and smoke detection for preaction systems).

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
6. Energize circuits to electrical equipment and devices.
7. Coordinate with fire-alarm tests. Operate as required.
8. Coordinate with fire-pump tests. Operate as required.
9. Verify that equipment hose threads are same as local fire-department equipment.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.13 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.14 PIPING SCHEDULE

A. Standard-pressure, wet-pipe sprinkler standpipe system, NPS 2 (DN 50) and smaller, shall be one of the following:
1. Schedule 40, Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

B. Standard-pressure, wet-pipe sprinkler standpipe system, NPS 2-1/2 and larger, shall be the following:
1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.15 TRAINING AND OPERATING INSTRUCTION

A. Train Owner's maintenance personnel to adjust, operate, and maintain sprinkler system.
1. Provide training to operating personnel in proper system operation and required user maintenance procedure.
2. Provide two 4-hour training session for operating personnel. These sessions are to cover proper operating and response procedures. These instructions shall be sufficient to enable a previously untrained person to properly operate the system.

B. Operating Instructions
1. At the completion of the work, provide a small scale plan of the building indicating the locations of all control valves, low point drains, and inspector’s test valves. The plan shall be neatly drawn and color coded to indicate the portion of the building protected by each system, framed under glass and permanently mounted on the wall adjacent to each floor control valve assembly.
2. Furnish two (2) copies of NFPA 25 and bound set(s) of printed operating and maintenance instructions to the Owner, and adequately instruct the Owner’s maintenance personnel in proper operation and test procedures of all fire protection components provided, furnished, or installed.

END OF SECTION

SECTION 22 0500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 REFER TO RELATED SECTIONS

A. Section 23 05 01 – Mechanical and Electrical Coordination
Section 23 05 02 – Basic Mechanical Requirements
Section 23 05 03 – Basic Mechanical Material and Methods
Section 23 05 13 – Motors and Starters
Section 23 05 21 – Pipe and Pipe Fittings
Section 23 05 22 – Piping Accessories
Section 23 05 23 – Valves
Section 23 05 29 – Pipe Support and Anchors
Section 23 05 30 – Electronic Speed Controllers
Section 23 05 48 – Vibration Control
Section 23 05 49 – Seismic Restraints
Section 23 05 53 – Mechanical Identification

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION 220500

SECTION 22 0700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 REFER TO RELATED SECTIONS

A. Section 23 07 00 – Mechanical Insulation

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION 220700

SECTION 22 0800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 REFER TO RELATED SECTIONS

A. Section 23 08 00 – Building Mechanical System Commissioning.
Section 23 08 01 – Commissioning Agent Requirements

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION 220800

SECTION 22 0900 - PLUMBING AUTOMATION AND AUTOMATIC TEMPERATURE CONTROL SYSTEM

PART 1 - GENERAL

1.1 GENERAL

A. Section 23 09 00 – Building Automation and Automatic Temperature Control Systems.

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION 220900

SECTION 22 1000 - PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract and Division 1 Specification Sections (General Requirements), apply to this Section.

1.2 SUBMITTALS

A. Submit manufacturer's data on the following:

1. Pressure reducing valves.
2. Backflow preventers.
3. Water hammer arresters.
4. Piping products, fitting and connection methods.
5. Roof drains, floor drains, floor sinks, cleanouts and area drains.
6. Downspout nozzles.
7. Backwater valves.
8. Water meter and meter pit.
9. Trap primers
10. Trap guards
11. Thermostatic mixing valves

1.3 STANDARDS

A. Materials shall comply with the following standards.

1. Cast iron pipe:
   a. ASTM A-74-87
   b. CISPI 301 (must bear trademark label on pipe)
2. Cast iron pipe fittings:
   a. ASTM A-888
   b. CISPI
3. Cast iron pipe couplings ASTM C-564
4. Copper pipe:
   a. Type K, L, M: ASTM B88
   b. DWV: ASTM B306-88
5. Ductile iron pipe: ASTM A377-89
6. All components in contact with potable water shall be listed for compliance to NSF 61 Lead Free requirements.
7. PVC PIPE AND FITTINGS
   a. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
   b. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns

1.4 RELATED WORK

A. Section 230529 Pipe Supports and Anchors.

PART 2 - PRODUCTS

2.1 DOMESTIC WATER PIPING AND ACCESSORIES

A. **Above Ground Inside Building,** Size 4" and Under:

1. Pipe: Copper tube, hard temper, Type L.
2. Fittings: Wrought copper, or cast bronze.
3. Solder: 95-5 tin antimony (no lead).
4. Refer to section 230521 for other acceptable joining methods for copper tube 4" and smaller.

B. **Below Ground Inside Building,** Size 2" and Under:

1. Pipe: Copper tube, annealed, Type K.
2. Fittings: Wrought copper, brazed.

C. **Below Ground Outside Building,** 2-1/2" and Over:

1. Ductile pressure pipe, tar coated, cement lined:
   a. Pipe: ANSI A21.51, Class 50.
   b. Fittings: ANSI 21.10.
   c. Rubber Gaskets: ANSI 21.11.

D. Use approved fittings for connections between dissimilar pipe systems.

2.2 DOMESTIC WATER PRESSURE REDUCING VALVE

A. Manufacturer:

1. Design Basis: Watts Model LF223S (1/2" through 2-1/2")
2. Other Acceptable Manufacturers:
   a. Febco
   b. Beeco
   c. Wilkins
3. Construction:
   a. Seal: Renewable, stainless steel.
   b. Strainer: Stainless steel.
   c. Diaphragm: High temperature resistant.
   d. Must comply with NSF 61 and NSF/ANSI 372

2.3 DOMESTIC WATER PRESSURE REDUCING VALVE

A. Manufacturer:

1. Design Basis: Watts Model: ACV M6115-74 (3" through 12")
2. Other Acceptable Manufacturers:
   a. Beeco
   b. Febco
   c. Wilkins
   d. Cla-valve
3. Construction: "Quadseal", non-edged seat, 100% fused epoxy finish, stainless steel seats through 8", FDA approved diaphragm.
4. Must comply with NSF 61 and NSF/ANSI 372.

2.4 BACKFLOW PREVENTER, (REDUCED PRESSURE ZONE TYPE) (FOOD SERVICE OTHER THAN CABONATORS AND COFFEE MAKERS)

A. Manufacturer:

1. Design Basis: Watts No.SS009QT Series
2. Construction: Stainless steel trim and body, complete with test cocks, resilient seat, shut-off valves, and air gap fitting.
3. Other Acceptable Manufacturers:
   a. Beeco
   b. Febco
   c. Wilkins
4. Complies with ASSE STD 1013
5. Must comply with NSF 61 and NSF/ANSI 372.

2.5 BACKFLOW PREVENTER, (DUAL CHECK WITH ATMOSPHERIC PORT) (FOOD SERVICE CARBONATORS AND COFFEE MAKERS)

A. Manufacturer:

1. Design Basis: Watts No.SD-3
2. Construction: 316 Stainless steel trim and body, NSF approved
3. Other Acceptable Manufacturers:
   a. Febco
   b. Wilkins
4. Extend vent to floor sink/drain
5. Complies with ASSE 1022
6. Must comply with NSF 61 and NSF/ANSI 372

2.6 BACKFLOW PREVENTER, (REDUCED PRESSURE ZONE TYPE) (DOMESTIC WATER SERVICE)

A. Manufacturer:

1. Design Basis: Watts No. LF909, (1/2" through 10")
2. Construction: Bronze body, stainless steel trim, complete with test cocks, resilient seat, shut-off valves, and air gap fitting. Provide with strainer.
3. Other Acceptable Manufacturers:

a. Febco
b. Wilkins

4. Complies with ASSE STD 1013.
5. Must comply with NSF 61 and NSF/ANSI 372.

2.7 BACKFLOW PREVENTER (DOUBLE CHECK) (FIRE PROTECTION SERVICE)

A. Manufacturer:

1. Design Basis: Watts No. 709 (2-1/2" through 10")
2. Construction: Epoxy coated cast iron body, replaceable bronze seats.
3. Other Acceptable Manufacturers:
   a. Beeco
   b. Febco
   c. Wilkins
4. Complies with ASSE STD 1015.

2.8 BACKFLOW PREVENTER (ATMOSPHERIC VACUUM BREAKER)

A. Manufacturer:

1. Design Basis: Watts No. LF008 Series (3/8" through 1")
2. Construction: Bronze body, ball valve shut offs.
3. Other Acceptable Manufacturers:
   a. Febco
   b. Wilkins
4. Complies with ASSE STD 1020.
5. Must comply with NSF 61 and NSF/ANSI 372.

2.9 WATER HAMMER ARRESTER (SHOCK ABSORBERS)

A. Manufacturers:

1. Design Basis: Zurn Shoktrol Z-1700
2. Construction: Stainless Steel, Bellows
3. Other Acceptable Manufacturers:
   a. Josam
   b. PPP, inc
   c. Sioux Chief
   d. J.R. Smith
4. Standards: PDI WH201, ASSE STD 1010.
5. Must comply with NSF 61 and NSF/ANSI 372.

2.10 TRAP PRIMERS (TP)

A. Manufacturers:

1. Design basis: PPP as noted in Plumbing Fixture Schedule.
2. Construction: Corrosion resistant brass. "O" rings shall have a flexibility range of -40°F to 450°F.

3. Provide distribution units for connector points as shown on plans.
4. Complies with ASSE STD 1018.
5. Must comply with NSF 61 and NSF/ANSI 372.

2.11 TRAP GUARDS (TG)

A. Manufacturers:

1. Design basis: ProSet Trap Guard
2. Construction: A flexible tube made of elastmeric material that is treated to roll up when water is passing through drain.
3. Install in floor drains and floor sinks from 2” up to and including 4” as shown on plans indicated with a (TG) behind drain designation.
4. Larger sizes can be custom made by ProSet upon request.
5. Use of trap guards as approved by local authority.

2.12 WATER METER

A. Provide meter, pit, and cover in accordance with Water Supplier’s standards and instructions.

1. Meter is furnished by Water Supplier at Contractor’s expense.
2. Meter shall be furnished by the Contractor in accordance with Water Supplier’s standard specification.

B. Meter shall be located in pit exterior to building.

C. Meter and pit shall be furnished and installed under civil division. Piping shall be extended to within 5’0” of building by site utility contractor. Mechanical contractor shall verify and coordinate location and elevation of connection point.

D. Refer to Mechanical BMS/BAS point connections and local water water department (IE. Remote Reader) for required connections to meter.

2.13 SANITARY AND VENT PIPING (WITHIN BUILDING)

A. Above Ground:

1. Cast iron hub and spigot, neoprene gasket.
2. Cast iron no hub, neoprene gasket and stainless steel sleeve joint.
3. DWV copper with DWV fittings, solder joint.

B. Exposed in finished spaces:

1. DWV copper with DWV fittings.

C. Underground:

1. Cast iron hub and spigot, neoprene gasket.
2. PVC schedule 40 - solid core (approved by local building department and Owner).

2.14 HEAVY DUTY NO HUB COUPLINGS

A. Use on the following:

1. Sanitary vent piping 4” and larger.
2. Sanitary piping 3” and larger.
3. All storm piping.

B. 1-1/2”, 2”, 3” and 4”: 3” wide 304 stainless steel shield; (4) minimum stainless steel clamps; fixed and “floating” eyelet.

C. 5” and over: 4” wide 304 stainless steel shield, with six (6) stainless steel clamps mounted in series.

D. Torque to minimum 80 inch pounds or per manufacturer’s recommendation.

E. Acceptable manufacturers: Husky Series 4000 or Mission Heavy Weight.

2.15 STANDARD DUTY COUPLINGS

A. Standard duty couplings shall conform to CISPI 310-85: 0.008” thick corrugated stainless steel.

B. Use of the following:

1. Sanitary vent piping up to and including 3” piping.
2. Sanitary piping up to and including 2” piping.

C. Torque to inch pounds per manufacturer’s recommendation.

D. Acceptable manufacturers: Tyler, Mission, AB&I, Clamp All, Huskey.

2.16 SOIL AND VENT PIPING PRODUCTS

A. Use approved fittings for connections between dissimilar pipe systems.

B. Manufacturers:

1. Acceptable Manufacturers:
   a. Josam
   b. Wade
   c. Zurn
   d. J.R. Smith
   e. Jones Spec
   f. Watts Ancon

C. Cleanout Plugs:

1. Material: Cast bronze or brass.
2. Type: Countersunk.
3. Threads: ANSI B2.1.

D. Wall Cleanout Covers:

1. Type: Frameless, round, low profile plate.
2. Material: Stainless steel or chrome plated brass.
3. Attachment: Single exposed flush screw.
4. Finish:
    a. Non-painted surfaces: Bright polished.
    b. Surfaces to be painted: Prime coat.

E. Floor Cleanouts:

1. Body: Standard round Duco cast iron.
2. Attachment: Bronze screws.
3. Sleeve: Full thickness of floor slab.
4. Top:
    a. Shape:
        1) Where floor covering has rectangular pattern: Square.
        2) Other areas: Round.
5. Cover:
    a. For Vinyl Tile and Similar Floor Coverings: Recessed to receive inset of floor material.
    b. For carpeted floor covering provide carpet cleanout marker.
    c. Other areas: Nickel bronze scoriated finish.
6. Provide heavy duty floor cleanouts for all areas accessible by vehicles or forklift traffic.

F. Exterior Cleanouts to Grade:

1. Material: Duco cast iron.
2. Ferrule: Caulk type.
3. Plug: Cast bronze countersunk type.

G. Vandal-Proof Caps

1. Material: Duco cast iron.
2. Attachment: Recessed Allen set screw.

H. Backwater Valve:

1. Material: Duco cast iron.
2. Valve: Bronze.
3. Provide cleanout cover.
    a. Locate in accessible manhole.

2.17 SANITARY SEWER PIPING (BELOW GRADE-EXTERIOR TO BUILDING)

A. Match material and methods specified in Division 2 for sitework sanitary sewer system or as listed below.

B. Use approved fittings for connections between dissimilar pipe systems.

C. Plastic Pipe:

1. Acceptable Manufacturers:
   a. Johns-Manville
   b. Carlon
   c. Robintech
2. Material: PVC ASTM D3034
3. Strength: SDR35

2.18 STORM WATER PIPING (INSIDE BUILDING)

A. Above Ground:

1. Cast iron, hub and spigot, neoprene gasket joints.
2. Cast iron no hub, neoprene gasket and stainless steel clamps.
3. Schedule 40 galvanized steel with screwed or grooved mechanical fittings. (Optional: Welded joints)

B. Underground:

1. Cast iron hub and spigot, neoprene gasket.
2. PVC schedule 40 - solid core (approved by local building department and Owner).

2.19 STORM WATER PIPING (BELOW GROUND-EXTERIOR TO BUILDING)

A. Match material and methods specified in Division 2 for sitework storm sewer system or as listed below.

B. Match materials and methods specified for soil and vent piping above.

C. Use approved fittings for connections between dissimilar pipe systems.

2.20 STORM DRAINAGE PRODUCTS

A. Acceptable Manufacturers:

1. Josam
2. Wade
3. Zurn
4. Jones Spec
5. Watts Ancon
6. J.R. Smith

B. Roof Drain: (RD)

1. Material: Cast Iron
2. Dome: Cast Iron
3. Include:
   a. Combined flashing collar and gravel stop.

b. Extension for insulation.
c. Under-deck clamp.
d. Sump receiver.
e. Expansion joint.

C. Overflow Roof Drain: (OD)

1. Same as Roof Drain Type 1 except:
   a. Provide water dam. Top of water dam shall be 2" above low point of roof or per local code if different.

D. Downspout Nozzle: (DSN)

1. Material: Cast bronze body and flange.

2.21 SAND AND OIL INTERCEPTOR

A. Materials:

1. Pre-formed or cast concrete.

B. Capacity: See plans.

C. Design:

1. Comply with local authority having jurisdiction.
2. Two compartment.
3. Two access manholes with ladders and manhole covers. Covers to be cast with "Sewer".
4. Design to be H20 loading in all traffic areas
5. See detail shown on plans for general requirements.

2.22 GREASE INTERCEPTOR

A. Materials:

1. Pre-formed or cast concrete.

B. Capacity: See plans.

C. Design:

1. Comply with local authority having jurisdiction.
2. Two compartment.
3. Two access manholes with ladders and manhole covers. Covers to be cast with "Sewer".
4. Design to be H20 loading in all traffic areas
5. See detail shown on plans for general requirements.

2.23 GREASE AND OIL TRAPS (INDIVIDUAL FIXTURE) (MANUAL)

A. Acceptable manufacturers:

1. Wade
2. Zurn
3. Josam
4. J.R. Smith

B. Construction: Fabricated steel with acid resistant coating inside and outside.

C. Capacity as noted on drawings. Manual type.

D. Accessories: Flow control fitting, removable baffles, threaded inlet and buffet, extension collar as required, internal air relief, double wall trap without cleanout and gasketed scoriated cover.

E. Approval Standard: Plumbing and Drainage Institute (PDI) approval.

2.24 GREASE TRAPS (INDIVIDUAL FIXTURE) (AUTOMATIC)

A. Furnish and install Thermaco Big Dipper Model No. W-350-IS, bright finish type 304 stainless steel exterior, rotationally molded polyethylene interior automatic self-cleaning grease and oil recovery separator(s) for floor mounted or partially recessed installation, rated at 35 gallons per minute (2.21 l/s) peak flow, 70 pounds (31.8 Kg) of grease capacity and including as an integral part of the unit, 1 rotating gear hydrophobic wheel assembly for automatic grease/oil removal, an integral flow control device, self-regulating enclosed electric immersion heater, a vessel vent, an integral gas trap, a digital control for programmable operation, a field reversible motor location, a field reversible grease/oil sump outlet, quick release stainless steel lid clamps, a gasketed and fully removable 304 stainless steel lid, a lift-out strainer basket access, an internal stainless steel strainer basket for collection of course solids, and a separate grease and oils collection container. Electric assembly shall be tested to comply with pertinent sections of the Standards for Safety ANSI/UL 73 and/or ANSI/UL 1004. Electric motor equipped with overload protection. Two (2) no-hub connectors for plumbing connection provided.

2.25 THERMOSTATIC MIXING VALVES

A. Master Type - ASSE 1017 Devices

B. Individual or Group - ASSE 1070 Devices

PART 3 - EXECUTION

3.1 GENERAL

A. Testing: Test in accordance with the applicable Plumbing Code.

B. Connections to Equipment Furnished Under Other Sections:

1. Make final connections to all equipment shown on drawings as connected to supply and/or drain piping.
2. Furnish all devices necessary for final connection, including:
   a. Tail pieces
   b. Stops
   c. Supplies

C. Corrosion Protection:

1. Provide isolation between concrete or mortar and any copper pipe.
2. All below grade piping shall be adequately protected from corrosion.

D. Comply with Section 23 05 29 Pipe Supports and Anchors for pipe support requirements.

3.2 INSTALLATION OF DOMESTIC WATER PIPING AND PRODUCTS

A. Install all horizontal water piping level and parallel to building construction. Make any changes in direction with fittings, don't kink or bend. All vertical piping to be plumb. Provide dielectric isolation between uninsulated pipe and hangers. Provide plastic grommets when going through metal studs. Tape is not acceptable for dielectric isolation.

B. Backflow Preventer:

1. Provide backflow preventer requirements as follows:
   a. Reduced pressure at Mechanical Equipment, ice plant, and make-up for hydronic systems.
   b. Vacuum breaker at all hose bibbs.
   c. Reduced pressure on water entry.
   d. Reduced pressure on irrigation systems.
   e. Stainless steel reduced pressure on water lines to carbonated beverage dispensers and ice makers.

C. Water Hammer Arrestors:

1. Provide water hammer arrestors in the piping systems and adjacent to all pieces of equipment wherein quick-closing vales are installed.
2. Water hammer arrestors shall be properly sized and selected per PDI Standard WH 201 and having sufficient displacement volume to dissipate the calculated kinetic energy generated by the piping system. Install all units in a vertical position.
3. Provide access panels.
4. Install water hammer arrestors as close as possible to inlet side of quick closure valves and devices.
5. Install water hammer arrestors in upright position on inlet side of solenoid valve.
6. Do not install water hammer arrestors at greater than 90-degree angle from vertical position.
7. Water hammer arrestors extended to above ceiling are not acceptable.

D. Disinfection:

1. After installation of all fixtures served, fill all domestic water lines with a chlorine-water solution of 50 parts per million minimum.
2. Hold solution in pipe for at least 24 hours.
3. Open and close all valves 3 times during chlorination.
4. Waste chlorine solution from each outlet.
5. Measure solution at end. If not 10 ppm, repeat.

E. Meters:

1. Install water meter in accordance with Water Supplier's standard.

F. Pressure Reducing Valves: Install pressure gauges upstream and downstream of all pressure reducing valves.

3.3 INSTALLATION OF SANITARY AND VENT PIPING

A. Couplings: See Part 2 for use of standard and heavy-duty couplings.

B. Gaskets: Install gaskets in accordance with manufacturer's recommendations for the use of lubricants, cements, and other special installation requirements.

1. Joint Adapters: Make joints between cast iron pipe and other types of pipe with standard manufactured cast iron adapters and fittings.
2. All no-hub couplings and fittings to be restrained from movement in accordance with CISPI Standard 310.

C. Joint Adapters: Make joints between cast iron pipe and other types of pipe with standard manufactured cast iron adapters and fittings.

D. Cleaning Piping:

1. Clear the interior of pipe of dirt and other superfluous material as the work progresses.
2. Place plugs in the end of uncompleted pipe at the end of the day or whenever work stops.

E. Test Plugs:

1. Provide test plugs in floor drains and roof drains at the time of installation.
2. Leave test plugs in place for the duration of construction until sewer or drainage system is complete.

F. Vent Flashing:

1. Provide 4 lb. sheet lead (24" x 24" minimum).
2. Extend lead 5" above the vent and turned down into vent pipe.
3. Refer to Section 7600 for single ply roof system components.

G. Vent Location: Do not install vents within 2 ft. of roof edge, parapet, wall line, or an "on-the-roof structure" and within 10 ft. of any air intake.

H. Cleanouts:

1. Provide cleanouts as required by code.
2. Provide cleanouts for end runs of all water closet, urinal and lavatory batteries.
3. Final locations of cleanouts to be approved by the Architect for all finish spaces.

I. Grease, and Sand/Oil Interceptors and Traps:

1. Provide solid unexcavated earth or concrete support under interceptors.
2. Do not support interior traps from floor extension.
3. Vents from these interceptors shall extend separately to the outdoors.

3.4 INSTALLATION OF STORM DRAINAGE PIPING (ABOVE GROUND WITHIN BUILDING)

A. Couplings:

1. Utilize heavy duty, 8 psi, no-hub couplings for cast iron. No-hub may only be used on piping within 20' below the roof. This limitation is to prevent a failure of the no-hub couplings in the event of a downstream system blockage. In lieu of this restriction adequate relief or coupling restraints per 3.4.A.3, must be provided and approved by the engineer.
2. Threaded or mechanical couplings with galvanized piping are acceptable for all locations.
3. All no-hub couplings and fittings to be restrained from movement in accordance with CISPI Standard 310.

B. Gaskets: Install gaskets in accordance with manufacturer's recommendations for the use of lubricants, cements, and other special installation requirements.

C. Joint Adapters: Make joints between cast iron pipe and other types of pipe with standard manufactured cast iron adapters and fittings.

D. Cleaning Piping:

1. Clear the interior of pipe of dirt and other superfluous material as the work progresses.
2. Place plugs in the end of uncompleted pipe at the end of uncompleted pipe at the end of the day or whenever work stops.

E. Test Plugs:

1. Provide test plugs in floor drains and roof drains at the time of installation.
2. Leave test plugs in place for the duration of construction.

F. Roof Drains:

1. Install drains on the center line of sheet lead pan.
2. Clamp flashing into drain flashing collar.

3. Install domes immediately after completion of roof installation.

G. Expansion:

1. Provide a vertical expansion joint at each connection to roof drain unless an offset is provided.
2. Where piping crosses building expansion joints, provide swing or expansion joints to allow for building movement.

H. Downspout Nozzles: Install with flange secured to wall at base of concealed storm leaders that discharge through the building wall above grade.

I. Provide sway bracing and anchorage of piping as required by local code. At a minimum provide sway bracing at changes of direction greater than 45 degrees for pipes 4" or larger.

3.5 INSTALLATION OF SANITARY SEWER AND STORM WATER PIPING (EXTERIOR TO BUILDING)

A. Couplings: See Part 2 for use of couplings.

B. Lay piping true to the grades and alignment indicated with unbroken continuity of invert.

C. Install gaskets in accordance with manufacturer's recommendations for the use of lubricants, cements and other special installation requirements.

D. Install plastic pipe in accordance with pipe manufacturer's written instructions.

E. Install cast iron hub and spigot pipe under roads and paved areas.

F. Clear the interior of piping of dirt and other superfluous material as the work progresses. Maintain a swab or drag in the line and pull past each joint as it is completed.

G. Place plugs in the end of uncompleted conduit at the end of the day or whenever work stops.

H. Flush lines if required to remove collected debris.

I. Make joints between cast iron pipe and other types of pipe with standard manufactured cast iron adapters and fittings.

J. Grout joints between cast iron pipe and concrete pipes thoroughly with cement mortar to make watertight joint.

K. Inspect conduit to determine whether line displacement or other damage has occurred.

1. Make inspection after lines between manholes, or manhole locations, have been installed and approximately 2 ft. of backfill is in place and at completion of the project.

L. If the inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, take whatever steps are necessary to correct such defects to the satisfaction of the Architect/Engineer.

M. Set grade cleanouts located in unpaved and asphalt paved areas in 12” x 12” x 4” concrete pad.

1. Provide concrete pad.

3.6 TRAP PRIMERS

A. Install all trap primers and required distribution units as shown on plans and as required by manufacturers recommendations.

3.7 TRAP GUARDS

A. Install elastmeric trap guards in specified floor and sink drains as indicated on plans.

END OF SECTION 221000

SECTION 221113 - FACILITY WATER DISTRIBUTION 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.

1.2 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for water service, fire-service mains and combined water service and fire-service mains.

B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.3 DEFINITIONS

A. PE: Polyethylene plastic.

B. DI: Ductile Iron.

1.4 SUBMITTALS

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

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
   1. Wiring Diagrams: Power, signal, and control wiring for alarms.

C. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
   2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. 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.

D. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

1.6 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.

1.7 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 Owner no fewer than 14 days in advance of proposed interruption of service.
   2. Do not proceed with interruption of water-distribution service without Owner's written permission.

1.8 COORDINATION

A. Coordinate connection to water main with utility company or agency.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.
   1. 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. Hard Copper Tube: ASTM B 88, Type K, water tube, drawn temper.
   1. 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.

C. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.

D. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Gaskets: AWWA C111, rubber.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.3 SPECIAL PIPE FITTINGS

A. Ductile-Iron Rigid Expansion Joints:
   1. 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:
      a. EBAA Iron, Inc.
      b. U.S. Pipe and Foundry Company.
   2. Description: Three-piece, ductile-iron assembly consisting of telescoping sleeve with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
      a. Pressure Rating: 250 psig (1725 kPa) minimum.

B. Ductile-Iron Flexible Expansion Joints:
   1. 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:
      a. EBAA Iron, Inc.
      b. Hays Fluid Controls; a division of ROMAC Industries Inc.
      c. Star Pipe Products.
   2. Description: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
      a. Pressure Rating: 250 psig (1725 kPa) minimum.

C. Ductile-Iron Deflection Fittings:

1. 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:
   a. EBAA Iron, Inc.
2. Description: Compound, ductile-iron coupling fitting with sleeve and 1 or 2 flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
   a. Pressure Rating: 250 psig (1725 kPa) minimum.

2.4 JOINING MATERIALS

A. Refer to Division 22 Section "Common Work Results for Plumbing" for commonly used joining materials.

B. Brazing Filler Metals: AWS A5.8, BCuP Series.

2.5 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Flexible Connectors:
1. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
2. Ferrous-Metal Piping: Stainless-steel hose covered with stainless-steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.

C. Dielectric Fittings: Combination of copper alloy and ferrous; threaded, solder, or plain end types; and matching piping system materials.
1. Dielectric Unions: Factory-fabricated union assembly, designed for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C). Include insulating material that isolates dissimilar metals and ends with inside threads according to ASME B1.20.1.
2. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure to suit system pressures.
3. Dielectric-Flange Insulation Kits: Field-assembled companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   a. Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure to suit system pressures.

4. Dielectric Couplings: Galvanized-steel couplings with inert and noncorrosive thermoplastic lining, with threaded ends and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
5. Dielectric Nipples: Electroplated steel nipples with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types, and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.6 CORROSION-PROTECTION PIPING ENCASEMENT

A. Encasement for Underground Metal Piping:
1. Standards: ASTM A 674 or AWWA C105.
2. Form: Sheet or tube.
3. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness.
4. Color: Black.

2.7 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:
1. 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:
   a. American AVK Co.; Valves & Fittings Div.
   b. American Cast Iron Pipe Co.; American Flow Control Div.
   c. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. East Jordan Iron Works, Inc.
   f. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
   g. McWane, Inc.; Kennedy Valve Div.
   h. McWane, Inc.; M & H Valve Company Div.
   i. McWane, Inc.; Tyler Pipe Div.; Utilities Div.
   j. Mueller Co.; Water Products Div.
   k. NIBCO INC.
   l. U.S. Pipe and Foundry Company.
2. Nonrising-Stem, Metal-Seated Gate Valves:
   a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.
      1) Standard: AWWA C500.
      2) Minimum Pressure Rating: 200 psig (1380 kPa).
      3) End Connections: Mechanical joint.
      4) Interior Coating: Complying with AWWA C550.

B. Bronze Gate Valves:
1. 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:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Div.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Red-White Valve Corporation.

2.8 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:
1. 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:
a. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
b. East Jordan Iron Works, Inc.
c. Flowserve.
d. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
e. McWane, Inc.; Kennedy Valve Div.
f. McWane, Inc.; M & H Valve Company Div.
g. Mueller Co.; Water Products Div.
h. U.S. Pipe and Foundry Company.
2. Description: Sleeve and valve compatible with drilling machine.
a. Standard: MSS SP-60.
b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
c. Valve: AWWA, cast-iron, nonrising-stem, metal resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches (125 mm) in diameter.
1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

2.9 CHECK VALVES

A. AWWA Check Valves:
1. 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:
a. American AVK Co.; Valves & Fittings Div.

b. American Cast Iron Pipe Co.; American Flow Control Div.
c. APCO Williamette; Valve and Primer Corporation.
d. Crane Co.; Crane Valve Group; Crane Valves.
e. Crane Co.; Crane Valve Group; Stockham Div.
f. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
g. McWane, Inc.; Kennedy Valve Div.
h. McWane, Inc.; M & H Valve Company Div.
i. Mueller Co.; Water Products Div.
j. NIBCO INC.
k. Watts Water Technologies, Inc.

2. Description: Swing-check type with resilient seat. Include interior coating according to AWWA C550 and ends to match piping.
   a. Standard: AWWA C508.
   b. Pressure Rating: 175 psig (1207 kPa).

2.10 CORPORATION VALVES AND CURB VALVES

A. Manufacturers:
   1. 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:
      a. Amcast Industrial Corporation; Lee Brass Co.
      b. Ford Meter Box Company, Inc. (The); Pipe Products Div.
      c. Jones, James Company.
      d. Master Meter, Inc.
      e. McDonald, A. Y. Mfg. Co.
      f. Mueller Co.; Water Products Div.
      g. Red Hed Manufacturing & Supply.

B. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.
   1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
   2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
   3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.

C. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

D. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches (75 mm) in diameter.

1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.11 WATER METERS

A. Water meters must be in conformance with DC WASA standards.

2.12 CONCRETE METER VAULTS

A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.
   1. Ladder: ASTM A 36/A 36M, steel or polyethylene-encased steel steps.
   2. Manhole: ASTM A 48/A 48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
      a. Dimension: 24-inch (610-mm) minimum diameter, unless otherwise indicated.
   3. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron traffic frame and cover.
      a. Dimension: 24-inch- (610-mm-) minimum diameter, unless otherwise indicated.
   4. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.13 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:
   1. 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:
      a. American AVK Co.; Valves & Fittings Div.
      b. American Cast Iron Pipe Co.; American Flow Control Div.
      c. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
      d. American Foundry Group, Inc.
      e. East Jordan Iron Works, Inc.
      f. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
      g. McWane, Inc.; Kennedy Valve Div.
      h. McWane, Inc.; M & H Valve Company Div.
      i. Mueller Co.; Water Products Div.
      j. Troy Valve; a division of Penn-Troy Manufacturing, Inc.
      k. U.S. Pipe and Foundry Company.
   2. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Include interior coating according to

AWWA C550. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.

a. Standard: AWWA C502.
b. Pressure Rating: 150 psig (1035 kPa) minimum.

3. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
   a. Standards: UL 246, FMG approved.
   b. Pressure Rating: 150 psig (1035 kPa) minimum.
   c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
   d. Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
   e. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
   f. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.

2.14 ALARM DEVICES

A. Alarm Devices, General: UL 753 and FMG approved, of types and sizes to mate and match piping and equipment.

B. Water-Flow Indicators: Vane-type water-flow detector, rated for 250-psig (1725-kPa) working pressure; designed for horizontal or vertical installation; with 2 single-pole, double-throw circuit switches to provide isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal when cover is removed.

C. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position.

D. Pressure Switches: Single pole, double throw; designed to signal increase in pressure.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Division 31 Section "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 (DN 20 to DN 80) shall be the following:
1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed copper, pressure-seal fittings; and pressure-sealed joints.

F. Underground water-service piping NPS 4 to NPS 8 (DN 100 to DN 200) shall be the following:
1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed or mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical joints.

G. Water Meter Box Water-Service Piping NPS 3/4 to NPS 2 (DN 20 to DN 50) shall be same as underground water-service piping.

H. Underground Fire-Service-Main Piping NPS 4 to NPS 12 (DN 100 to DN 300) shall be the following:
1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed or mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical joints.

I. Underground Combined Water-Service and Fire-Service-Main Piping NPS 6 to NPS 12 (DN 150 to DN 300) shall be the following:
1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed or mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical joints.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 (DN 80) and larger underground installation. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 (DN 50) and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Underground Valves, NPS 3 (DN 80) and Larger: AWWA, cast-iron, nonrising-stem, metal seated gate valves with valve box.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

A. See Division 22 Section "Common Work Results for Plumbing" for piping-system common requirements.

3.5 PIPING INSTALLATION

A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

B. Make connections larger than NPS 2 (DN 50) with tapping machine according to the following:
   1. Install tapping sleeve and tapping valve according to MSS SP-60.
   2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
   3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
   4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

C. Make connections NPS 2 (DN 50) and smaller with drilling machine according to the following:
   1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
   2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
   3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
   4. Install corporation valves into service-saddle assemblies.
   5. Install manifold for multiple taps in water main.
   6. Install curb valve in water-service piping with head pointing up and with service box.

D. Comply with NFPA 24 for fire-service-main piping materials and installation.
   1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
   2. Install copper tube and fittings according to CDA's "Copper Tube Handbook."

E. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
   1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.

F. Bury piping with depth of cover over top at least 48 inches, with top at least 12 inches below level of maximum frost penetration, and according to the following:
   1. Under Driveways: With at least 48 inches (910 mm) cover over top.

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. Sleeves are specified in Division 22 Section "Common Work Results for Plumbing."

I. Mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

J. 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.

K. See Division 21 Section "Water-Based Fire-Suppression Systems" for fire-suppression-water piping inside the building.

L. See Division 22 Section "Domestic Water Piping" for potable-water piping inside the building.

3.6 JOINT CONSTRUCTION

A. See Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.

B. Make pipe joints according to the following:
   1. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
   2. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
   3. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure. Refer to Division 22 Section "Common Work Results for Plumbing" for joining piping of dissimilar metals.

3.7 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
   1. Concrete thrust blocks.
   2. Locking mechanical joints.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
   1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
   2. Fire-Service-Main Piping: According to NFPA 24.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

C. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.9 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to utility company's written instructions.

3.10 CONCRETE VAULT INSTALLATION

A. Install precast concrete vaults according to ASTM C 891.

3.11 FIRE HYDRANT INSTALLATION

A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.

B. AWWA Fire Hydrants: Comply with AWWA M17.

3.12 ALARM DEVICE INSTALLATION

A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.

B. Connect alarm devices to building fire alarm system. Wiring and fire-alarm devices are specified in Division 28 Section "Fire Detection and Alarm."

3.13 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. See Division 22 Section "Common Work Results for Plumbing" for piping connections to valves and equipment.

C. Connect water-distribution piping to utility water main. Use tapping sleeve and tapping valve.

D. Connect water-distribution piping to interior domestic water and fire-suppression piping.

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.14 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 Tests: Test at not less than one-and-one-half times working pressure for two hours.
   1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.15 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 Division 31 Section "Earth Moving."

B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Division 22 Section "Common Work Results for Plumbing" for identifying devices.

3.16 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 prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
   3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
      a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
      b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
      c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION

SECTION 221313 - FACILITY SANITARY SEWERS

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 gravity-flow, nonpressure sanitary sewerage outside the building, with the following components:
   1. Special fittings for expansion and deflection.
   2. Backwater valves.
   3. Cleanouts.
   4. Precast concrete and Cast-in-place concrete manholes.

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Special pipe fittings.

B. Shop Drawings: For the following:
   1. Manholes: Include plans, elevations, sections, details, and frames and covers. Include design calculations, and concrete design-mix report for cast-in-place manholes.

C. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

D. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch

equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

E. Field quality-control test reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

1.7 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 fourteen days in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without Architect's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.3 PVC PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 35 with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

B. PVC Sewer Pipe and Fittings, NPS 18 and Larger: ASTM F 679, T-[1] wall thickness, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.4 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:
   1. For Plastic Pipes: ASTM F 477, elastomeric seal.
   2. For Dissimilar Pipes: Material compatible with pipe materials being joined.

2.5 CLEANOUTS

A. Gray-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
   1. Available Manufacturers:
      a. Josam Company.
      b. MIFAB Manufacturing Inc.
      c. Smith, Jay R. Mfg. Co.
      d. Wade Div.; Tyler Pipe.
      e. Watts Industries, Inc.
      f. Watts Industries, Inc.; Enpoco, Inc. Div.
      g. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

   2. Top-Loading Classification: Light, Medium, Heavy and Extra-heavy duty.

   3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

   1. Available Manufacturers:
      a. Canplas Inc.
      b. IPS Corporation.
      c. NDS Inc.
      d. Plastic Oddities, Inc.
      e. Sioux Chief Manufacturing Company, Inc.

f. Zurn Light Commercial Specialty Plumbing Products; Zurn Plumbing Products Group.

2.6 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
   1. Diameter: 48 inches minimum, unless otherwise indicated.
   2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
   3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
   4. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
   5. Top Section: Eccentric-cone type, unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
   6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
   7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
   8. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
   9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
   10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
   11. Protective Coating: Plant-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 15-mil minimum thickness applied to exterior surfaces.
   12. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch- minimum width flange and 26-inch- diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
       a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.
       b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 15-mil minimum thickness applied to all surfaces, unless otherwise indicated.

B. Cast-in-Place-Concrete Manholes: Construct of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.
   1. Ballast: Increase thickness of concrete as required to prevent flotation.

2. Resilient Pipe Connectors: ASTM C 923 cast or fitted into manhole walls, for each pipe connection.
3. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
4. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
5. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
6. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch- minimum width flange and 26-inch- diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
    a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 15-mil minimum thickness applied to all surfaces, unless otherwise indicated.

2.7 CONCRETE

A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
    a. Invert Slope: 2 percent through manhole.
2. Benches: Concrete, sloped to drain into channel.
    a. Slope: 4 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
   1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
   2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

2.8 MISCELLANEOUS MATERIALS

A. Paint: SSPC-Paint 16.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING APPLICATIONS

A. Pipe couplings and special pipe fittings 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, increaser/reducer-pattern, flexible or rigid couplings for pipes with different OD.
      b. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

B. Special Pipe Fittings: Use for pipe expansion and deflection. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

C. Gravity-Flow, Nonpressure Sewer Piping: Use any of the following pipe materials for each size range:
   1. NPS 4: ABS, SDR 35, sewer pipe and fittings; gaskets; and gasketed joints.
   2. NPS 4: PVC sewer pipe and fittings, gaskets, and gasketed joints.
   3. NPS 5 and NPS 6: NPS 6 ABS, SDR 35, sewer pipe and fittings; gaskets; and gasketed joints.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewerage piping. Location and arrangement of piping layout take design considerations into account. 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 using lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into existing sewer is indicated.

D. 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.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.

F. Install gravity-flow, nonpressure, drainage piping according to the following:
1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
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 piping with 48-inch minimum cover.
4. Install piping below frost line.
5. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

3.4 PIPE JOINT CONSTRUCTION

A. Basic piping joint construction is specified in Division 22 Section "Common Work Results for Plumbing" Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. Join gravity-flow, nonpressure, drainage piping according to the following:
1. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
2. Join dissimilar pipe materials with nonpressure-type, flexible or rigid couplings.

C. Join force-main, pressure piping according to the following:
1. Join dissimilar pipe materials with pressure-type couplings.

3.5 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Construct cast-in-place manholes as indicated.

D. Form continuous concrete channels and benches between inlets and outlet.

E. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.6 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

3.7 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
   1. Use light-duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
   2. Use medium-duty, top-loading classification cleanouts in paved foot-traffic areas.
   3. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
   4. Use extra-heavy-duty, top-loading classification cleanouts in roads.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.

C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.8 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Division 22 Section "Sanitary Waste and Vent Piping."

B. 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. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall, unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
    a. Use concrete that will attain minimum 28-day compressive strength of 3000 psi, unless otherwise indicated.
    b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.9 CLOSING ABANDONED SANITARY SEWERAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
    1. Close open ends of piping with at least 8-inch- thick, brick masonry bulkheads.
    2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes: Excavate around manhole as required and use either procedure below:
    1. Remove manhole and close open ends of remaining piping.
    2. Remove top of manhole down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Division 31 Section "Earth Moving."

3.10 PAINTING

A. Clean and prepare concrete manhole surfaces for field painting. Remove loose efflorescence, chalk, dust, grease, oils, and release agents. Roughen surface as required

to remove glaze. Paint the following concrete surfaces as recommended by paint manufacturer:

1. Cast-in-Place-Concrete Manholes: All exterior, except bottom.
2. Precast Concrete Manholes: All exterior.

B. Prepare ferrous frame and cover surfaces according to SSPC-PA 1 and paint according to SSPC-PA 1 and SSPC-Paint 16. Do not paint surfaces with foundry-applied corrosion-resistant coating.

3.11 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "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 Ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.12 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 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. 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. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
   a. Allowable leakage is maximum of 50 gal. /inch of nominal pipe size per mile of pipe, during 24-hour period.
   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.
   f. Option: Test ductile-iron piping according to AWWA C600, "Hydrostatic Testing" Section. Use test pressure of at least 10 psig.
6. Force Main: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig.
   a. Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
   b. PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.
7. Manholes: Perform hydraulic test according to ASTM C 969.

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.

3.13 CLEANING

A. Clean interior of piping of dirt and superfluous material. Flush with potable water.

END OF SECTION

SECTION 222123 - NATURAL GAS SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and Install:

1. Natural gas piping.
2. Valves and specialties.

B. Gas Meter: The gas meter and piping upstream of meter will be provided by the Gas Utility Company and paid for by this Contractor.

1.2 SUBMITTALS

A. Manufacturer's Product Data: Submit for:

1. Gas cocks.
2. Gas meter.
3. Emergency shut-off valves and relays.
4. Pressure reducing valves.

PART 2 - PRODUCTS

2.1 NATURAL GAS PIPING

A. 2 Inch and Smaller: Schedule 40 black steel with 150 lb. malleable iron threaded fittings.

B. Over 2 Inch: Schedule 40 black steel with standard weight steel butt weld fittings and welded joints.

C. Underground pipe shall be coated with PVC.

1. Pipe shall be listed by IAPMO, and bear the UPC logo.
2. Fittings shall be wrapped with PVC tape.
3. Tape shall conform to IAPMO Standard PS 22-84.
4. Provide cathodic protection where required by the local authority having jurisdiction.

D. All piping within return air plenums or concealed (unaccessible) in building construction shall be as called for piping over 2".

2.2 NATURAL GAS PIPING

A. Above Ground:

1. Two Inch and Smaller:
   a. Pipe: Schedule 40 black steel.
   b. Fittings: 150 lb. malleable iron, threaded.
2. Over Two Inch:
   a. Pipe: Schedule 40 black steel, plain end.
   b. Fittings: Standard weight, butt weld.

B. Underground:

1. Pipe: Schedule 40 black steel, ASTM A53, Grade B, seamless, plain end.
2. Fittings: Standard weight, steel.
   a. Two Inches and Smaller: Socket weld.
   b. Over Two Inch: Butt weld.
3. Coating:
   a. Pipe: AAPCA TGF-3.
   b. Fittings: Protecto Wrap No. 200.
      1) Primer: No. 1170

2.3 GAS COCKS

A. Description: Corrosion-resistant plug, permanently lubricated, corrosion-resistant bearings, suitable seals for intended service, lever operator.

2.4 PRESSURE REGULATING VALVES

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris.
   b. American Meter Company.
   c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   d. Invensys.
   e. Richards Industries; Jordan Valve Div.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig (690 kPa).

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris.
   b. American Meter Company.
   c. Eclipse Combustion, Inc.
   d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   e. Invensys.
   f. Maxitrol Company.
   g. Richards Industries; Jordan Valve Div.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig (13.8 kPa)

2.5 EMERGENCY GAS VALVES AND CONTROL STATIONS

A. Control Station: ASCO No. 108D906, key operated to open switch, pushbutton to close with pilot light.

1. Stainless steel face plate for flush mounting.
2. “GAS VALVE CONTROL” to be inscribed on the plate.
3. Key switch labeled “ON”.
4. Pushbutton labeled “OFF”.

B. Valve: ASCO No. 8215, 2-way solenoid, 110 volt, 60 Hz, AC.

1. Normally closed.

2.6 GAS OUTLET

A. Manufacturers:

1. Apollo
2. Legend
3. Milwaukee

B. Description:

1. AGA and/or UL certified for use with natural gas.
2. Ball valve, non lubricated.
3. soft seats, suitable for tight shut-off with low pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Remove cutting and threading burrs before assembling piping.

B. Do not install defective piping or fittings.

C. Do not use pipe with threads which are chipped, stripped or damaged.

D. Use teflon tape on male pipe threads.

E. Plug each gas outlet, including valves with a threaded plug or cap, immediately after installation, and retain until continuing piping or equipment connection is completed.

F. Do not install any valves or unions inside concealed areas or above ceiling in building.

G. Vent gas PRVs outside the building in accordance with local code.

H. Paint all exposed gas pipe with a minimum of 2 coats on rust resistant pipe.

3.2 BURIED PIPE

A. Coated Pipe: Follow IAPMO Standard IS 13-84.

B. Buried piping shall be buried 24” minimum.

1. All buried joints shall be welded and left exposed until testing has been completed.

3.3 EMERGENCY SHUT-OFFS

A. Install emergency shut-off valves where shown.

B. Deliver switches and relays to Installer of electrical work.

3.4 TEST

A. Prior to initial operation, test and purge fuel gas piping in accordance with local code requirements or the National Fuel Gas Code.

1. Test at 65 psig minimum.
2. Repair or replace piping as required to eliminate leaks, and re-test.

END OF SECTION 222123

SECTION 22 3000 - PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data for the following:

1. Domestic water heaters.
2. Domestic hot water storage tanks.
3. Pumps.
4. Startup report for gas fired heaters.
5. Warranty and service policies.

1.2 WARRANTY

A. Water Heater and Storage Tank:

1. Furnish a certificate of warranty outlining all specifics of heater manufacturer's warranty.
2. The warranty shall be a minimum of 15 years on all gas fired product and 25 years on all non-gas fired products.
3. The heater shall have a first year service policy including labor, troubleshooting, and parts, all to be serviced by the manufacturer's representative.
4. Initiation and/or continuation of warranty coverage shall not be dependent upon annual inspections, regular replacement of anode rods, water chemistry, or rust.
5. Complete copies of all warranties and service policies, including all exclusions and conditions, shall be presented to the owner as part of the submittal package.

B. Burner and Heat Exchanger: The burner and all heater parts will have a one-year warranty. Heat exchanger and combustion chamber will have a 15-year warranty covering manufacturing or material defects, leaks, and/or the production of rusty water.

C. Storage Tanks:

1. Storage tanks shall have a 25-year warranty covering manufacturing or material defects, leaks, and/or the production of rusty water.

1.3 POLLUTION CONTROL STANDARDS

A. All gas-fired water heaters shall comply with California's South Coast Air Quality Management District (SQAQMD) air pollution control district standards for emission of NOx and other gasses.

1.4 QUALITY ASSURANCE

A. The water heater will operate at a minimum thermal efficiency as scheduled when tested by an independent laboratory to ANSI Z21.10.3 (DOW 10 CFR 431). The water heater will comply

with the current ASHRAE 90.1 requirements.

B. The water heater will be constructed and stamped in accordance with Section IV, Part HLW of the ASME code and be National Board listed.

C. All water heaters used in food service applications shall be NSF approved.

D. Gas water heaters shall be compliant with ANSI Z.21.10.3 or UL 795.

E. Water heaters shall be U.L, ETL or CSA certified as a complete unit.

F. All components in contact with potable water shall comply with NSF standards.

PART 2 - PRODUCTS

2.1 GAS FIRED WITH INTEGRAL STORAGE TANK

A. Manufacturers:

1. Design Basis: PVI Industries, L.L.C.
2. Other Acceptable Manufacturers:
   a. A.O. Smith
   b. Bradford White
   c. State
   d. Ruud-Rheem
   e. Hubbell

B. Construction:

1. Water heaters will be of the BTU input(s) and storage capacity indicated on the equipment schedule.
2. The water heater will be a vertical fire tube, design that is constructed and stamped in accordance with Section IV, Part HLW of the ASME code. Water heater will be National Board Registered for a working pressure of 150 psi and will be pressure tested at 1-1/2 times working pressure.
3. Water heater will be a down-fired, fire tube design contained within an integral storage tank.
4. Tank, combustion chamber and fire tubes will be unlined. Lined or plated water heaters will NOT be acceptable.
5. Tank, combustion chamber and fire tubes will be constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21% chromium to prevent corrosion and mill certified per ASTM A 923Methods A to ensure that the product is free of detrimental chemical precipitation that affects corrosion resistance. The material selected shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2and ASTM G123 - 00(2005) “Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution.”
6. Tank will be welded utilizing joint designs to minimize volume of weld deposit and heat input. All heat affected zones (HAZ) shall be processed after welding to ensure the HAZ

corrosion resistance is consistent with the mill condition base metal chemical composition. Weld procedures (amperage, volts, welding speed, filler metals and shielding gases) utilized shall result in a narrow range of austenite-ferrite microstructure content consistent with phase balanced objectives for welds, HAZ and the base metal.

7. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces. Other passivation and pickling methods are not accepted. Immersion passivation and pickling certification documents are required and shall be provided with each product.
8. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems. Storage tank materials shall contain more than 80% post-consumer recycled materials and be 100% recyclable.
9. All water contacting tank surfaces will be non-porous and exhibit 0% water absorption.
10. All tank connections/fittings will be non-ferrous or stainless steel.
11. To preserve thermal efficiency, the water heater will not use or require a circulator piped from the hot water outlet to the cold water inlet of the heater for the purpose of temperature control during normal operation. Connection for a building return circulation line will be made to a dedicated hot return fitting at the center of the storage vessel and not the cold inlet piping. Connection to a sidearm tank, if used, will be made to a dedicated hot return fitting at the center of the storage vessel and not the cold inlet piping.
12. Finished vessel will **NOT** require sacrificial or impressed current anodes and none will be used. Water heaters or sidearm storage tanks that employ anode rods of any type will **NOT** be acceptable.
13. Combustion will be provided by a premix, fan-assisted surface burner with a gas train meeting UL, ANSI and FM standards for the input specified.
14. Burner will be stainless steel.
15. Gas train components will capable of self-proportionating gas and air to maintain optimum combustion in response to varying vent pressures.
16. At 199,000 to 399,000 BTU input, the burner will be fixed input.
17. At 500,000 BTU input and higher, the burner will employ non-linkage modulation utilizing only a VFD drive to vary gas and air.
18. Burner NOx emissions will be less than 20 ppm when corrected to 3% oxygen.
19. Water heater will be a category IV, condensing appliance and vent through PVC or Polypropylene. Water heater will satisfy requirements for sealed combustion. Vents for inlet air and exhaust can terminate in different pressure zones.

2.2 PERFORMANCE

A. Water heater will meet the thermal efficiency and standby heat loss requirements of the latest version of the ASHRAE 90.1 standard.

B. Water heater will be certified by the DOE/EPA Energy Star program for commercial water heaters, whereby standby loss and thermal efficiency are independently tested and certified.

C. Water heater will be third party tested and certified to NSF 5.

D. Water heaters will be third party tested and certified to NSF/ANSI 372 standard for lead content.

2.3 WATER HEATER TRIM

A. As a minimum, the heater will be equipped with the following:

1. electronic flame monitoring
2. electronic low water cutoff
3. an *immersion* operating control
4. an *immersion* UL listed temperature limiting device
5. an ASME- rated temperature and pressure relief valve

B. Operating and safety controls shall meet the requirements of UL 795 and FM

C. The water heater shall employ an electronic operating control with digital temperature readout. Operator shall be capable of connecting to a building automation system through serial connection using Modbus RTU protocol.

2.4 ELECTRIC WATER HEATER

A. Manufacturers:

1. Design Basis: PVI
2. Other acceptable manufacturers:
   a. State
   b. Rheem
   c. Rudd
   d. Bradford White
   e. A.O. Smith
   f. Hubbell
   g. Vaughn

B. Construction:

1. The storage section of the water heater shall be ASME HLW stamped and National Board Registered for a maximum allowable working pressure of 150 psi and pressure tested at 1-1/2 times working pressure.
2. All tank connections/ fittings shall be nonferrous. Tank shall be equipped with a ball-type drain valve. Tank design will include a manway sized access to the tank interior.
3. The storage tank shall be an unlined pressure vessel constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21% chromium to prevent corrosion and mill certified per ASTM A 923Methods A to ensure that the product is free of detrimental chemical precipitation that affects corrosion resistance. The material selected shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2and ASTM G123 - 00(2005) “Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution.”
4. Waterside surfaces shall be welded internally utilizing joint designs to minimize volume of weld deposit and heat input. All heat affected zones (HAZ) shall be processed after welding to ensure the HAZ corrosion resistance is consistent with the mill condition base metal chemical composition. Weld procedures (amperage, volts, welding speed, filler metals and shielding gases) utilized shall result in a narrow range of austenite-ferrite

microstructure content consistent with phase balanced objectives for welds, HAZ and the base metal.

5. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces. Other passivation and pickling methods are not accepted. Immersion passivation and pickling certification documents are required and shall be provided with each product.
6. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems. Storage tank materials shall contain more than 80% post-consumer recycled materials and be 100% recyclable.
7. Water contacting tank surfaces will be non-porous and exhibit 0% water absorption.
8. Lined or plated storage tanks will not be acceptable.
9. Water heaters that require anodes will not be acceptable.
10. Heating elements will be rated at 9 kW and 40 watts per square inch heat density Heating elements will be sheathed in Incoloy. Each element will individually mount to the tank by means of a four-bolt bronze flange over stainless steel studs with an o-ring seal. A fused magnetic contactor will be supplied for each power circuit. Maximum current per circuit will be 50 amps on three-phase units.

C. PERFORMANCE

Water heater will meet the requirements of ASHRAE 90.1– 2010.

D. WATER HEATER TRIM

E. As a minimum, the heater will be equipped with the following:

1. electronic low water cutoff
2. an *immersion* operating thermostat
3. *immersion* temperature limiting device
4. an ASME rated temperature and pressure relief valve

F. Operating and safety controls shall meet the requirements of UL

2.5 TANKS

A. Domestic Hot Water Storage Tanks:

1. Manufacturers:
   a. Design Basis: PVI
   b. Other Acceptable Manufacturers:
      1) Rheem
      2) Rudd
      3) State
      4) Lochinvar
      5) A.O. Smith
      6) Hubbell
2. Type: Vertical
3. Construction:

a. The storage section of the water heater shall be ASME HLW stamped and National Board Registered for a maximum allowable working pressure of 150 psi and pressure tested at 1-1/2 times working pressure.
b. All tank connections/ fittings shall be nonferrous. Tank shall be equipped with a ball-type drain valve. Tank design will include a manway sized access to the tank interior.
c. The storage tank shall be an unlined pressure vessel constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21% chromium to prevent corrosion and mill certified per ASTM A 923Methods A to ensure that the product is free of detrimental chemical precipitation that affects corrosion resistance. The material selected shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2and ASTM G123 - 00(2005) "Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution."
d. Waterside surfaces shall be welded internally utilizing joint designs to minimize volume of weld deposit and heat input. All heat affected zones (HAZ) shall be processed after welding to ensure the HAZ corrosion resistance is consistent with the mill condition base metal chemical composition. Weld procedures (amperage, volts, welding speed, filler metals and shielding gases) utilized shall result in a narrow range of austenite-ferrite microstructure content consistent with phase balanced objectives for welds, HAZ and the base metal.
e. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces. Other passivation and pickling methods are not accepted. Immersion passivation and pickling certification documents are required and shall be provided with each product.
f. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems. Storage tank materials shall contain more than 80% post-consumer recycled materials and be 100% recyclable.
g. Water contacting tank surfaces will be non-porous and exhibit 0% water absorption.
h. Lined or plated storage tanks will not be acceptable.
i. Water heaters that require anodes will not be acceptable.

4. PERFORMANCE

a. Water heater will meet the tank insulation requirements of ASHRAE 90.1-2010

5. WATER HEATER TRIM
a. ASME-rated temperature and pressure relief valve

2.6 PUMPS

A. General:

1. Statically and dynamically balance rotating parts.
2. Construction shall permit complete servicing without breaking piping or motor connection.

3. Pumps operate at 1750 rpm unless scheduled otherwise.
4. Pump connections shall be flanged.

B. In-Line Circulating Pumps:

1. Manufacturers:
   a. Design Basis: Bell & Gossett.
   b. Other Acceptable Manufacturers:
      1) Armstrong
      2) Taco
2. Description:
   a. Type: In-line circulating pumps.
   b. Casing: Bronze for 125 psi working pressure.
   c. Impeller: Bronze.
   d. Shaft: Steel with copper sleeve or stainless steel.
   e. Bearings: Oil lubricated, bronze, sleeve.
   f. Seal: Carbon rotating against a stationary ceramic seat, rated for 225ºF.
3. Pump components in contact with domestic water system shall meet the requirements of NSF/ANSI Standard 61.

C. Oil-Minder Sump Pumps (Elevator Pits):

1. Manufacturers:
   a. Design Basis: Stancor
   b. Other acceptable manufacturers:
      1) Weil
2. Provide pump and control systems capable of pumping water while containing oil. The system shall function automatically and shall provide for an alarm and separate LED lights in the event of:
   a. The presence of oil in the sump
   b. High liquid in the sump, or
   c. High amps or a locked rotor condition.
3. LED lights shall be provided for:
   a. Power
   b. Pump run function.
4. Pump:
   a. The pump shall be a submersible type, capable of pumping up to 37’ TDH and 74 GPM.
   b. The pump shall be approved to UL 778 standards and shall include thermal and overload protection.
   c. The motor shall be rated ½ H.P., 1 phase, 115V and capable of operating continuously or intermittently.
   d. The motor housing shall be constructed of #304 stainless steel and mechanical seats shall be housed in a separate oil-filled compartment.
5. Control:
   a. The main control shall be approved to UL 508 standards and housed in a gasketed NEMA 4X enclosure with a see-through window for observation of operating functions.
   b. The control shall be equipped with an 8-pin twist lock receptacle, dual solid state Oil-Minder relays with variable sensitivity settings, an over current relay, self-

cleaning stainless steel sensor probe, high decibel warning horn with alarm silencing switch, dual floats, clearly marked terminal board and remote monitoring contact.

c. A Nema 4X junction box with 8-pin twist-lock electrical receptacle and 25' (additional lengths available in 25' increments) of mating 8 conductor cable shall be provided.
d. All cables between the pump and junction box shall be 16' long and the cable and plug from the control unit shall be 8' long.
e. The control unit, junction box, pump, floats and sensor shall be factory assembled as a complete, ready-to-use system and shall be tested and approved as a complete system by a nationally recognized testing laboratory.
f. The system shall allow for the main control to be located outside of the elevator hoistway to be monitored for all functions without having to enter the elevator shaft.

2.7 INSTANTANEOUS POINT-OF-USE ELECTRIC WATER HEATER

A. Acceptable Manufacturers:

1. Chronomite
2. Eemax
3. Hubbell

B. Construction and Accessories:

1. Stainless steel heating elements.
2. Built-in temperature shutoff at 190 degrees.
3. 0.5 GPM inline flow control fitting.
4. Flow switch activated at 0.4 GPM and shutoff at 0.3 GPM

PART 3 - EXECUTION

3.1 DOMESTIC HOT WATER HEATER

A. Installation:

1. Make connections between water heaters and domestic water piping system with dielectric unions.
2. Install isolation valves at both cold water and hot water connections to water heater.
3. Furnish and install copper drain piping from temperature and pressure relief valve for water heater.
   a. Furnish drain full size of relief valve opening and extend as indicated.

B. Adjusting:

1. Provide start-up and adjustment by factory authorized personnel. A copy of the start up report will be provided to the owner.
2. Upon completion of water heater installation, verify satisfactory control operation under maximum demand conditions as recommended by manufacturer.

3. Adjust discharge water temperature as required. Make control adjustments required.

3.2 IN LINE CIRCULATING PUMPS

A. Install pumps to allow complete removal without dismantling connecting piping. Provide air cock and drain connection on horizontal pump casings.

B. Provide line sized gate valve and strainer on suction and line sized soft seated check valve and globe valve or plug valve on discharge.

C. Support pump and piping so that weight of pipe is not carried on pump casing. Additionally, support such that neither pump nor piping is supported by associated equipment.

D. Provide manual switch and aquastat where required.

E. Verify motor position is in accordance with manufacturer's installation instructions.

3.3 SUMP PUMPS

A. Provide union in discharge piping above floor.

B. Provide gate valve above floor.

C. Provide lift check valve close to pump discharge.

D. Install and adjust float control.

E. Manufacturer's Representative to be present for Start-Up and provide test report. Test pump staging and float operation by flooding pit to simulate operation. Test shall be observed by Engineer or Owner Representative.

F. Elevator Sump Pump Control Panels – Panels will be located out from high end spaces. Coordinate location and provide additional controls and power cables as required.

END OF SECTION 223000

SECTION 22 4000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data for plumbing fixtures and accessories, in accordance with Division 1.

B. LEED Submittals: Credit WE 3.1 and 3.2: Product Data for plumbing fixtures indicating water consumption.

PART 2 - PRODUCTS

2.1 GENERAL

A. All manufacturers are listed in alphabetical order and not by preference.

B. Provide factory fabricated fixtures.

C. Provide trim, carriers, valves and accessories as required for complete installation.

D. All carriers are floor mounted unless otherwise noted. All carriers shall be bolted down to floor structure.

E. Refer to Drawings for "Plumbing Fixture Schedule".

F. Comply with Local, State and Governing ordinances concerning maximum water requirements of plumbing fixtures: Tank type W.C. and flush valve type W.C. = 1.28 gal./flush; lavs = .5 GPM; urinals = 0.5 or .125 gal./flush and showers = 2.0 gal. maximum.

G. All valves, fixtures and accessories in contact with domestic water shall meet the requirements of NSF/ANSI Standard 61. Exception includes toilets, etc.

2.2 PLUMBING FIXTURES

A. Acceptable Manufacturers:

1. Water Closets, Urinals, Lavatories:
   a. American Standard
   b. Crane
   c. Kohler
   d. Eljer
   e. Toto
   f. Zurn

2. Faucets:
   a. American Standard
   b. Cambridge Brass
   c. Chicago
   d. Delta
   e. Kohler
   f. Sloan
   g. Symmons
   h. Toto
   i. Zurn
   j. Moen
3. Flush Valves
   Piston Type Flush Valves
   a. Sloan (Gem 2)
   b. Toto
   c. Kohler
   d. Zurn

B. Water Closets:

1. Unless otherwise specified, all water closets are vitreous china water saver type, white.
2. All flush valves, stops and supplies are to be chrome plated brass. Flush valves to be non hold open type. See section 2.3.

C. Urinals:

1. Unless otherwise specified, all urinals are vitreous china water saver type, white.
2. All flush valves are to be chrome plated brass, non hold open. See section 2.3.

D. Lavatories:

1. Unless otherwise specified, all lavatories are white.
2. Provide chrome plated brass angle stops, supplies, tail piece, P trap and grid strainer for all lavatories.
3. Provide offset P traps on all ADA lavatory installations.

2.3 FLUSH VALVES

A. Exposed piston type, brass construction chrome plated flush valve. Valve will have ADA compliant handle, angle stop with check valve, outlet tube with vacuum breaker, spud nut, escutcheon and wall flange. Valve will be in compliance with applicable sections of ASSE 1037, and ANSI A117.1 requirement for people with disabilities.

2.4 WATER CLOSET SEATS

A. Acceptable Manufacturers:

1. Beneke
2. Centoco

3. Church

B. Construction: Unless otherwise specified seats shall be heavy duty solid plastic, white with open front, concealed self substaining check hinge less cover. Seat shall have an antimicrobial compound as an integral part of the plastic and shall match shape of bowl (elongated or regular).

2.5 MOP SINK BASIN

A. Manufacturers:

1. Design Basis: See “Plumbing Fixture Schedule” on drawings.
2. Other Acceptable Manufacturers:
   a. Fiat Products
   b. Mustee
   c. Stern Williams

B. Material: Terrazzo

C. Mount: Floor

D. Faucet: Chrome plated with vacuum breaker, integral check valves, pail hook and wall brace.

E. Drain: Stainless steel, flat strainer, 3” IPS.

2.6 SHOWER VALVES

A. Acceptable Manufacturers:

1. American Standard
2. Bradley
3. Delta
4. Cambridge Brass
5. Chicago
6. Kohler
7. Leonard
8. Speakman
9. Symmons

B. Features: Single handle, automatic pressure and temperature balancing, and volume control, forged brass body with ceramic valving, adjustable temperature stop and polished chrome handle.

C. Hand held shower to be non-positive control to comply with ADA and shall be equipped with either an integral check valve or a vacuum breaker.

D. Heads and Arm: Polished chrome plated brass.

E. Shower valves shall turn off from hot to cold.

2.7 STAINLESS STEEL SINKS

A. Acceptable Manufacturers:

1. Elkay
2. Kohler
3. Just

B. Material: 18 gauge, type 304, stainless steel.

C. Mounting: Countertop, self-rimming.

D. Trap: 1½" adjustable, cast brass.

E. Stops: Loose key, ½" FPT, flexible supply, flange.

F. Provide chrome plated brass tailpiece and grid strainer.

G. ADA accessible sinks shall not exceed 6 ½" in depth.

2.8 GARBAGE DISPOSER

A. Acceptable Manufacturers:

1. In-Sink-Erator
2. Kitchenaid
3. Maytag
4. Waste King

B. Features:

1. Continuous feed.
2. Stainless sink flange.

2.9 FLOOR SINKS

A. Acceptable Manufacturers:

1. Josam
2. JR Smith
3. Wade
4. Zurn
5. Watts Ancon

B. Body: Cast iron with acid-resisting porcelain enameled interior.

C. Rim and Grate: Nickel bronze

D. Provide with clamping collars with water proof membrane clamps

2.10 FLOOR DRAINS

A. Acceptable Manufacturers:

1. Josam
2. JR Smith
3. Wade
4. Zurn
5. Watts Ancon

B. Body: Duco cast iron, with flashing collar.

C. Grates and sediment strainers as specified in schedule.

D. Provide primer taps as specified in schedule.

E. Provide with clamping collars with water proof membrane clamps.

2.11 ELECTRIC WATER COOLERS

A. Acceptable Manufacturers:

1. Cordley
2. Elkay
3. Halsey Taylor
4. Haws
5. Oasis
6. Sunroc

B. Industry Standards: Provide water coolers with UL and ARI labels, and which meet or exceed standards of the Safe Drinking Water Act and Lead Contamination Control Act, NSF Standard 61, Section 9. (Proposition 65 in California.) All components in the waterway to be lead free.

C. Evaporator and Chiller: All copper construction.

D. Accessories:

1. Automatic pressure regulator.
2. Stop and supply.
3. Cast brass P-trap.
4. Provide bottle filler when indicated.
5. Front push button activation.
6. Removable grid strainer.
7. Required mounting frame.

E. Finish: Heavy gauge stainless steel with No. 4 satin finish.

F. Units to meet all NSF and ADA standards.

2.12 DRINKING FOUNTAINS

A. Acceptable Manufacturers:

1. Cordley
2. Elkay
3. Halsey Taylor
4. Haws
5. Oasis
6. Sunroc

B. Industry Standards: Provide drinking fountains and/or cuspidor which meet or exceed standards of the Safe Drinking Water Act and Lead Contamination Control Act, NSF Standard 61, Section 9. (Proposition 65 in California.) All components in the waterway to be lead free.

C. Accessories:

1. Automatic pressure regulator.
2. Stop and supply.
3. Cast brass P-trap.
4. Provide bottle filler when indicated.
5. Front push button activation.
6. Removable grid strainer.
7. Required mounting frame.

D. Finish: Heavy gauge stainless steel with No. 4 satin finish.

E. Units shall meet all NSF and ADA standards.

2.13 WASHING MACHINE WALL BOX

A. Acceptable Manufacturers:

1. Guy Gray
2. Symmons

B. Material: Brass.

C. Connections:

1. ½" CW and HW. (Supplies from top or bottom as indicated)
2. 2" drain.

2.14 EQUIPMENT FURNISHED UNDER OTHER SECTIONS

A. Provide all materials necessary to make final connections to owner equipment furnished under other Sections of these Specifications including:

1. Tail pieces
2. Stops

3. Supplies
4. P traps, standard and/or offset
5. Escutcheons

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install each fixture with P trap with cleanout plug, easily removable for servicing and cleaning.

B. Provide chrome plated, rigid or flexible supplies to fixtures with stops, reducers and escutcheons.

C. Finish wall and floor penetrations when exposed to view in finished areas with set screw type, chrome plated brass escutcheons.

D. Set plumbing fixtures level and plumb, spaced in accordance with architectural dimensioned drawings, and securely install to be rigid.

E. Install wall mounted lavatories, urinals and water closets with wall carriers mounted to the floor.

F. Solidly attach floor mounted carriers for all fixtures to floor using proper fasteners based on floor construction.

G. Cover fixture bolts with china bolt caps of the same color where required.

H. All wall mounted fixtures to be caulked between fixture and wall.

I. Securely anchor flush valves behind or within walls to be rigid and not subject to movement due to push or pull action on the valve.

J. Fixture Mounting Heights:

1. Refer to Architectural drawings and ADA standards.

K. Floor Drains:

1. Refer to Architectural drawings for exact locations and additional installation requirements.
2. Install floor drains with P-traps and vent as required.
3. Install drains on the center line of sheet lead pan and/or membrane in waterproofed areas and in floors above lowest floor.
4. Clamp pan and/or membrane into drain flashing collar.
5. Install strainers immediately after completion of finish floor installation.
6. Coordinate locations with mechanical equipment.
7. Install trap primers as indicated.

L. All exposed piping serving plumbing fixtures that may be used for ADA purposes shall have traps and supplies insulated per ADA requirements.

M. Install flushing mechanism for both ADA accessible flush valves and flush tanks to the side of water closet that has the most floor space per ADA requirements. Provide for ADA prescribed clearances between the top of the flush valve and grab bars.

N. Provide a tempering valve that conforms to ASSE 1070 for all lavatories and sinks used as a public hand wash facility.

3.2 ADJUSTING AND CLEANING

A. Cleaning:

1. Clean strainers, traps, aerators, and valves of debris, sand and dirt.
2. At completion, thoroughly clean plumbing fixtures and equipment.

B. Adjusting: After cleaning and flushing operations are accomplished, adjust flush valves, faucets, showers, bubblers for proper flow.

3.3 PROTECTION

A. Protect fixtures and related components from damage before, during, and after installation to date of Final Acceptance or Owner move-in. Provide protective coverings or other protection as required.

B. Inspect each installed unit for damage to finish. If feasible, restore and match finish to original at site; otherwise, remove fixture and replace with new unit.

C. Feasibility and match to be judged by Architect or Engineer.

D. Remove cracked or dented units and replace with new units.

E. Contractor shall be responsible for replacing damaged fixtures or components.

END OF SECTION 224000

SECTION 22 9000 - PLUMBING PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 REFER TO RELATED SECTIONS

A. Section 23 90 00 – Project Closeout

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION 229000

SECTION 23 0501/26 0501 - MECHANICAL AND ELECTRICAL COORDINATION

PART 1 - GENERAL

1.1 RESPONSIBILITY

A. The Divisions 21 through 23 and 26 through 28 contractor(s) shall comply with the provisions of this section. The Divisions 21 through 23 contractor(s) shall verify electrical service provided by the electrical contractor before ordering any mechanical equipment requiring electrical connections. Provide submittals of all mechanical equipment to Division 26 through 28 contractor(s).

B. The final responsibility for properly coordinating the electrical work of this section shall belong to the Divisions 21 through 23 system contractor performing the work, which requires the electrical power.

1. Each Divisions 21 through 23 contractor shall be responsible for providing power wiring for certain devices as described in the specifications and on the drawings. This work shall be provided by a licensed electrician in accordance with all of the applicable provisions of the Division 26 through 28 specifications, NEC and local codes.

1.2 WORK INCLUDED

A. Carefully coordinate the interface between Divisions 21 through 23 (Mechanical) and Divisions 26 through 28 (Electrical), and Division 23 09 00 (Building Management and Automatic Temperature Control Systems) before submitting any equipment for review or commencing installation.

1.3 DEFINITIONS

A. Automatic: Pertaining to a function, operation, process or device that, under specified conditions, functions without intervention by human operator.

B. Disconnect Switch: A mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a power source.

C. Motor Control Center: A floor mounted assembly of one or more enclosed vertical sections having a common horizontal power bus and primarily containing motor starting units.

D. Control Circuit/Power: The circuit which carries the electrical signals of a control apparatus or system directing the performance of the controller but does not carry the main power circuit.

E. Manual Operation: Operation by hand without the use of any other power.

F. MC: Mechanical Contractor = Divisions 21 through 23 Contractor who furnishes motor.

G. TC: Temperature Controls = Division 23 09 00 Contractor who furnishes control.

H. EC: Electrical Contractor = Divisions 26 through 28 Contractor.

I. FA: Fire Alarm Contractor = Division 28 Contractor who furnishes Fire Alarm System.

J. EP: Electric to Pneumatic Converter.

K. PE: Pneumatic to Electric Converter.

1.4 RESPONSIBILITY SCHEDULE

A. Responsibility: Unless otherwise indicated, all motors and controls for Divisions 21 through 23 equipment shall be furnished, set in place and wired in accordance with the following schedule:

ITEM -	**Furnished Under**	**Set In Place Under**	**Power Wiring Under**	**Control Wiring Under**
MC: Mechanical Contractor TC: Temperature Contractor EC: Electrical Contractor FA: Fire Alarm Contractor				
AHU Interior Marine Lights	MC	MC	EC	MC
Equipment Motors	MC	MC	EC	--
Automatically or Manually Controlled Starters/Contactors: (Note 4) -Separate -Factory Mounted and Wired	 MC MC	 EC MC	 EC EC	 TC TC
In Motor Control Centers (Note 4)	EC	EC	EC	TC
Motor Speed Controllers: (Note 4) -Separate -Factory Mounted and Wired	 MC MC	 EC MC	 EC EC	 TC TC
Disconnect Switches (Note 1)	EC	EC	EC	--
Thermal Overload Switches (Note 1)	EC	EC	EC	--
Switches (Manual or Automatic other than disconnect) (Note 2)	MC or TC	MC or TC	EC or TC	TC or MC
Control Relays (Note 2)	MC or TC	MC or TC	--	TC
Control Transformers	MC or TC	MC or TC	EC or TC	TC
Push Button Stations, Pilot Lights	MC	EC	EC	EC
Thermostat and Controls: Integral with Equipment or Directly Attached to Ducts, Pipes, etc. (Note 2)	MC or TC	EC or TC	EC or TC	TC
Equipment in Temperature Control Panels	TC	TC	TC	TC
Standalone Control Panels (BAS) (Note 6)	TC	TC	TC	TC
Valve Motors, Damper Motors, Solenoid Valves, etc.	TC	TC	TC	TC
EP Valves or Switches, P.E. Switches, etc.	TC	TC	--	TC
Fire Alarm System (Note 3)	FA	FA	EC	FA
Fire Sprinkler Alarm (Note 3)	MC	MC	EC	FA
Duct System Smoke Detectors (Note 5)	FA	MC	--	TC/FA

ITEM -	**Furnished Under**	**Set In Place Under**	**Power Wiring Under**	**Control Wiring Under**
MC: Mechanical Contractor TC: Temperature Contractor EC: Electrical Contractor FA: Fire Alarm Contractor				
Relays for Fan Control via duct detectors (Note 5)	MC	MC	EC	TC
Room Smoke Detectors Including Relays for Fan Control (Note 3)	FA	FA	--	FA
Smoke Management Controls (Note 7)	FA	FA	EC	FA
CO Sensors	TC	TC	TC	TC
Control Air Compressor	TC	TC	TC	TC
Refrigerated Air Dryer	TC	TC	TC	TC
Equipment Interlocks	TC	TC	--	TC
Fire/Smoke and Smoke Dampers (Note 7)	MC	MC	EC	FA
Smoke Control Dampers (for smoke management system)	MC	MC	EC	FA/TC
Positive Indication Devices (i.e., current sensors, end switches, airflow sensors)	TC	TC	--	FA/TC

Notes:

1. If furnished as part of factory wired equipment furnished and set in place by MC, wiring and connections by EC.
2. If float switches, line thermostats, P.E. switches, time switches, or other controls carry the FULL LOAD CURRENT to any motor, they shall be furnished by MC, but they shall be set in place and connected by EC, except that where such items are an integral part of the mechanical equipment, or directly attached to ducts, piping, or other mechanical equipment, they shall be furnished and set in place by MC and connected by EC. If they do not carry the FULL LOAD CURRENT to any motor, they shall be furnished, set in place and wired by TC contractor.
3. Pre-action system initiation signals (such as smoke detectors or general alarm conditions in a pre-action zone) shall be provided under Division 28.
4. Electrical contractor is responsible for wiring from starter to motor, unless factory wired.
5. Temperature control contractor shall provide conduit and wire from auxiliary contact in motor starter to the detector so that the unit shuts down in all operating modes. Fire Alarm Contractor to wire from detector to fire alarm panel.
6. Each division shall be fully responsible for any control panels as called for on the drawings or specifications.
    a. Division 26 shall provide all power and control wiring to fire/smoke or smoke dampers. Division 23 and 26/28 shall provide parallel control wiring (with 28 fire alarm having priority signal) to dampers and equipment utilized in both normal and smoke control modes. Refer to Smoke Control and Fire Alarm Drawings and the Fire Alarm Matrix.
    b. Fire alarm system shall override automated building control system during smoke exhaust mode.
    c. TC wiring required only when damper also serves HVAC system.

7. FA wires to components necessary for the operation and monitoring of the Smoke Management System. TC wires to components utilized in the control and monitoring of the Automated Building Control System.

B. Power Wiring by Divisions 21 through 23: The electrical power for certain equipment provided under Divisions 21 through 23 has not been specifically indicated on the electrical drawings and must be provided by and field coordinated by the Divisions 21 through 23 trade requiring such power.

Sufficient power for this purpose shall be furnished as "spare" dedicated circuit capacity in Division 26's panelboards. All wiring, conduit and electrical devices downstream of the panelboards are the responsibility of the Divisions 21 through 23 trade requiring the power.

1. Such equipment is hereby defined as:
   a. Electrical heat trace. Required heat trace locations, capacities and specification are shown on the plumbing drawings (Division 22 work).
   b. Fire protection air compressors, dry-pipe control panels and valves. Required connections are included in the Division 21 work, and will be shown by that contractor's engineered system design drawings.
      1) Pre-action system initiation signals (such as smoke detectors or general alarm conditions in a pre-action zone) shall be provided under Division 28 fire alarm work.
      2) Division 21 shall provide pre-action control panel and interconnection between nearest suitable fire alarm panel and location of pre-action valve(s).
      3) Division 28 shall provide interconnection between fire command center alarm panel (provided under Division 28**)** and remote communication fire alarm panel (provided under Division 28**).**
   c. Infrared plumbing fixtures. Fixtures requiring power are shown on the plumbing drawings and schedules. Provide junction box and or receptacle as required by manufacturer.
   d. Temperature control panels, control air compressors and line voltage power for 24v control transformers. Required connections are included in Division 23 09 00 and will be shown by that contractor's control submittal drawings.
   e. Condensate pumps. Provide power from associated unit or from nearby panelboard.

1.5 GENERAL REQUIREMENTS

A. Connections:

1. Connections to all controls directly attached to ducts, piping and mechanical equipment shall be made with flexible connections.

B. Starters:

1. Provide magnetic starters for all three phase motors and equipment complete with:
   a. Control transformers.
   b. 120V holding coils.
   c. Integral hand-off-auto switch.
   d. Auxiliary contacts required for system operation plus one (1) spare.

e. Refer to Section 23 05 13 Motors, Starters and Drives.

C. Remote Switches and Pushbutton Stations:

1. Provide remote switches and/or pushbutton stations required for manually operated equipment (if no automatic controls have been provided) complete with pilot lights of an approved type lighted by current from load side of starter.

D. Special Requirements:

1. Motors, starters and other electrical equipment installed in moist areas or areas of special conditions, such as explosion proof, shall be designed and approved for installation in such areas with appropriate enclosure.

E. Identification:

1. Provide identification of purpose for each switch and/or pushbutton station furnished. Identification may be either engraved plastic sign permanently mounted to wall below switch, or stamping on switch cover proper. All such identification signs and/or switch covers in finished areas shall match other hardware in the immediate area.

F. Control Voltage:

1. Maximum allowable control voltage 120V. Fully protect control circuit conductors in accordance with National Electrical Code.

G. DDC Control Interface:

1. Fully coordinate the requirements of each division with regard to supplying a complete DDC Control System prior to submitting bid.
2. All control power shall be furnished via dedicated line voltage circuits.
3. Dedicated control circuits from electrical panelboards to DDC control panels and from electrical panelboards to dedicated DDC J-boxes (for distributed control components such as VAV boxes), and control transformer line voltage connections shall be provided under Division 23 09 00 where required and as shown on the drawings.
    a. Exceptions: The following Divisions 21 through 23 equipment has been provided with electrical power feeders downstream of the panelboards by Division 26:
        1) Division 28, Fire Alarm System Panels.
        2) Division 23 09 00, Building Automation System (BAS):
        3) Each air handling unit (AHU) has been provided with a dedicated combination control and unit lighting circuit(s) to its air handling room.
        4) Certain BAS panels requiring emergency power.
        5) BAS workstations and file servers in the engineer’s office and fire command center.
        6) See the drawings for additional exceptions.
4. Low voltage wiring from J-boxes to distributed control components, all low voltage connections, all control panels and all control transformers (not part of unitary equipment) shall be provided under Division 23 09 00.

5. Any additional power requirements shall be the responsibility of the Division 23 09 00 Contractor requiring same, and provided at no additional cost to the owner.

1.6 CEILING AND CHASE CAVITY PRECEDENCE

A. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of precedence. A system with higher precedence may direct that systems of lower precedence be relocated from space, which is required for expedient routing of the precedent system.

1. Plumbing waste, cooling coil drain piping, and roof drain mains and leaders.
2. Hydronic main piping (12" and larger).
3. Plumbing vent piping.
4. Supply, return and exhaust ductwork.
5. Electrical conduit greater than 4" diameter.
6. Hydronic branch and mains (greater than 2", but less than 12").
7. Domestic water piping.
8. Fire sprinkler mains and leaders.
9. Hydronic branch piping (2" and less).
10. Domestic hot and cold water branches.
11. Electrical conduit branch feeders.
12. Pneumatic control piping.
13. Fire sprinkler branch piping and sprinkler runouts.

B. Light fixtures have precedence in a zone, which is the same height above the ceiling as the depth of the fixture (plus 2").

C. Examine the contract documents of all trades (e.g. all Divisions 21 through 23 and 26 through 28 drawings, the architectural floor plans, reflected ceiling plans, elevations and sections, structural plans and sections, etc.).

D. Coordinate necessary equipment, ductwork and piping locations so that the final installation is compatible with the materials and equipment of the other trades.

E. Prepare shop drawings for installation of all new work before installation to verify coordination of work between trades.

F. Provide access doors for all equipment, valves, clean-outs, actuators and controls which require access for adjustment or servicing and which are located in otherwise unaccessible locations.

1. For equipment located in "accessible locations" such as lay-in ceilings: Locate equipment to provide adequate service clearance for normal maintenance without removing architectural, mechanical, electrical or structural elements such as the ceiling support system, electrical fixtures, etc. "Normal maintenance" includes, but is not limited to: filter changing; greasing of bearings; using p/t ports for pressure or temperature measurements; and replacement of ballasts, fuses, etc.

PART 2 - PRODUCTS

2.1 MOTOR HORSEPOWER

A. In general, all motors ¾ HP and above shall be three phase, all motors ½ HP or less shall be single phase.

B. Voltage and phase of motors as scheduled on the electrical drawings shall take precedence in the case of a conflict between the mechanical and electrical drawings or general condition 2.1. A., above.

C. Work under Divisions 21 through 23 includes coordinating the electrical requirements of all mechanical equipment with the requirements of the work under Divisions 26 through 28, before ordering the equipment.

1. If motor horsepowers are changed under the work of Divisions 21 through 23 without a change in duty of the motor's driven device, coordination of additional electrical work (if any) and additional payment for that work (if any) shall be provided under the section of Divisions 21 through 23 initiating the change. Increases or decreases in motor horsepower from that specified shall not be made without written approval from the Architect/Engineer.

PART 3 - EXECUTION - (Not Used)

END OF SECTION 230501 & 260501

SECTION 23 0502 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1 - General Requirements.

B. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. Architect/Engineer shall decide which is more stringent.

C. Provisions of this section shall also apply to all sections of Divisions 21 through 23.

1.2 DEFINITIONS

A. The definitions of Division 1 and the General Conditions of this specification also apply to Divisions 21 through 23 contract.

B. “Contract Documents” constitute the drawings, specifications, general conditions, project manuals, etc., prepared by Engineer (or other design professional in association with Engineer) for contractor’s bid or contractor’s negotiations with the Owner. Divisions 21 through 23 drawings and specifications prepared by the Engineer are not construction documents.

C. “Construction Documents”, “construction drawings”, and similar terms for Divisions 21 through 23 work refer to installation diagrams, shop drawings and coordination drawings prepared by the contractor using the design intent indicated on the Engineer’s contract documents. These specifications detail the contractor’s responsibility for “Engineering by Contractor” and for preparation of construction documents.

D. “(N)” indicates "new" equipment to be provided under this contract.

E. “(E)” indicates "existing" equipment on site which may or may not need to be relocated as a part of this work.

F. “(R)” indicates existing equipment to be relocated as part of this work.

G. "Furnish" means to "supply" and usually refers to an item of equipment.

H. "Install" means to "set in place, connect and place in full operational order".

I. "Provide" means to "furnish and install".

J. “Equal” or "Equivalent" means "meets the specifications of the reference product or item in all significant aspects." Significant aspects shall be as determined by the Architect/Engineer.

K. "Work by other(s) divisions"; "re:_____ Division", and similar expressions means work to be performed under the contract documents, but not necessarily under the division or section of the work on which the note appears. It is the contractor’s sole responsibility to coordinate the work

of the contract between his/her suppliers, subcontractors and employees. If clarification is required, consult Architect/Engineer before submitting bid. By inference, any reference to a "contractor" or "sub-contractor" means the entity, which has contracted with the Owner for the work of the Contract Documents.

L. By inference, any reference to a "contractor" or "sub-contractor" means the entity, which has contracted with the owner for the work of the Contract Documents.

M. "Engineer" means the design professional firm, which has prepared these contract documents. All questions, submittals, etc. of this division shall be routed to the Engineer (through proper contractual channels).

1.3 COORDINATION WITHIN DIVISIONS 21 THROUGH 23

A. Contract Documents:

1. General: The Contract Documents are diagrammatic showing certain physical relationships, which must be established within the Divisions 21 through 23 work and its interface with other work. Such establishment is the exclusive responsibility of the Contractor. Drawings shall not be scaled for the purpose of establishing material quantities.
2. Supplemental Instructions: The exact location for some items in this Specification may not be shown on the Drawings. The location of such items may be established by the Architect/Engineer during the progress of the work.
3. Discrepancies:
    a. Examine Drawings and Specifications of all Divisions of the work.
    b. Report any discrepancies to the Architect/Engineer and obtain written instructions before proceeding.
    c. Should there be a conflict within or between the Specifications or Drawings, the more stringent or higher quality requirements shall apply.
    d. Items called for in either specifications or drawings shall be required as if called for in both.
4. Constructability:
    a. Examine Drawings and Specifications of all Divisions of the work.
    b. Report any issues to the Architect/Engineer which may prevent installation of Divisions 21 through 23 work in accordance with the Contract Documents and the original construction contract.
    c. Report all issues within ***90 days*** after contract.

B. Be responsible for providing proper documentation of equipment product data and shop drawings to all entities providing service. This coordination shall include, but not be limited to the following:

1. Division 21 - Series contractor (Fire Protection Contractor) shall provide shop drawings to all other Division 21 through 23 contractors.
2. Division 23 09 00 and 23 05 93 - Contractors (Automatic Temperature Controls, Building Management and Test-Adjust-Balance Contractors) shall be provided with equipment product data and shop drawings as appropriate from other Division 21 through 23 and Divisions 26 through 28 contractors, and shall furnish the same information about control

devices (such as valves, test wells, etc.) to the appropriate Divisions 21 through 23 Contractor.

C. Coordination Drawings:

1. Submit coordination drawings for all Divisions 21 through 23 work. The drawings shall be fully coordinated and signed off by all affected trades prior to submission. The coordination drawings shall include the following at a minimum.
   a. All major ductwork, piping, conduit and equipment.
   b. Reflected ceiling plans with light fixtures.
   c. Current architectural floor plans.
   d. Major structural elements.
   e. Elevations of piping ductwork or equipment.
   f. Sections through critical spaces.
2. The drawings shall be at a suitable scale (1/8”=1’-0” minimum) to clearly show information.
3. Any work installed without approved coordination drawings is done at the Contractor’s risk.

D. CAD Drawings:

1. Electronic Auto Cad drawings are available for purchase from M-E Engineers.

E. Existing Conditions:

1. Inspect existing conditions prior to bidding.
2. Provide proper coordination of mechanical work with existing conditions.

F. Utility Connections:

1. Coordinate the connection of mechanical system with the Civil drawings and utility companies.
2. Comply with regulations of utility suppliers.
3. The Contract Documents indicate the available information on existing utilities and services, and on new services (if any) to be provided to the project by utility companies and agencies.
   a. Notify Architect/Engineer immediately if discrepancies are found.
4. Coordinate mechanical utility interruptions one week in advance with the Owner and the Utility Company.
   a. Plan work so that duration of the interruption is kept to a minimum.

1.4 COORDINATION WITH OTHER DIVISIONS

A. General:

1. Coordinate Divisions 21 through 23 work to the progress of the work of other trades.
2. Complete the entire installation as soon as the condition of the building will permit.
3. The project will be constructed under multiple bid packages. Coordinate this Division’s work with the progress of the other bid package’s work.

B. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order:

1. Plumbing waste, cooling coil drain, piping and roof drain mains and leaders.
2. Hydronic main piping (12" and larger).
3. Plumbing vent piping.
4. Supply, return and exhaust ductwork.
5. Electrical conduit greater than 4" diameter.
6. Hydronic branch and mains (greater than 2", but less than 12").
7. Domestic water piping.
8. Fire sprinkler mains and leaders.
9. Hydronic branch piping (2" and less).
10. Domestic hot and cold water branches.
11. Electrical conduit branch feeders.
12. Pneumatic control piping.
13. Fire sprinkler branch piping and sprinkler runouts.

C. Coordination with Electrical Work. Refer to Section 23 05 01.

D. Cutting and Patching: Refer to Division 1 and Section 23 05 03.

E. Chases, Inserts and Openings:

1. Provide measurements, drawings, and layouts so that openings, inserts and chases in new construction can be built in as construction progresses.
2. Check sizes and locations of openings provided.
   a. Any cutting and patching made necessary by failure to provide measurements, drawings, and layouts at the proper time shall be done at no additional cost to the Owner.
   b. Coordinate roof openings for all roof-mounted equipment. Openings on documents are diagrammatic and do not represent manufacturer specific requirements. Actual opening size, orientation and location, as well as structural coordination, is the responsibility of the mechanical contractor.
   c. Provide transitions on ductwork to accommodate actual roof openings.

F. Support Dimensions: Provide dimensions and drawings so that concrete bases and other equipment supports to be provided under other Sections of the Specifications can be built at the proper time.

1.5 COORDINATION WITH EXISTING OCCUPIED AREAS

A. Minimize disruptions to operation of mechanical systems in occupied areas.

B. Coordinate any required disruptions with the Owner, one week in advance.

C. Provide temporary connections to prevent long disruptions.

1.6 ENGINEERING BY CONTRACTOR

A. The construction of this building requires the contractor to design several systems or subsystems. All such designs shall be the complete responsibility of the contractor.

B. Systems or subsystems which require engineering responsibility by the contractor include, but are not limited to:

1. Any system not fully detailed on the drawings.
2. Fire sprinkler.
3. Equipment supports, and hangers not fully detailed in the drawings.
4. Pipe hangers and anchors not specified in these documents, or cataloged by the manufacturer.
5. Duct supports, hangers and miscellaneous steel as required.
6. Temperature controls.
7. Refrigeration systems.
8. Piping expansion and contraction provisions.
9. Equipment supports, hangers.
10. Ice plant and ice floor systems.

1.7 REGULATORY REQUIREMENTS

A. Codes: Comply with the following:

1. District of Columbia Building Code.
2. District of Columbia Mechanical (HVAC) Code.
3. District of Columbia Plumbing Code.
4. National Electric Code.
5. ASME Boiler and Pressure Vessel Code.
6. Local Modifications to above Codes.
7. District of Columbia Fire Prevention Code.
8. District of Columbia Energy Conservation Code.

B. Applicable pamphlets of NFPA.

C. Requirements of Local Utility Companies:

1. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required for the project.

D. Other Regulations: Comply with the latest editions of the following:

1. U.S. and State Department of Labor Safety Regulations pertaining to the completed project.
2. Requirements of Fire Departments serving the project.
3. Regulations of the Health Department having jurisdiction.
4. Regulations of the Office of State Fire Marshal.
5. ASHRAE Energy Conservation Standard 90A.
6. ASHRAE Ventilation Standard 62.
7. Requirements of the State Oil Inspector.
8. Americans with Disabilities Act (ADA).

9. Clean Air Act.
10. Clean Water Act.
11. LEED v4 Edition.

E. Additional Regulations: Follow additional regulations, which appear in individual Sections of these Specifications.

F. Contradictions: Where codes are contradictory, follow the most stringent, unless otherwise indicated in Plans or Specifications. Architect/Engineer shall determine which is most stringent.

G. Contract Documents Not in Compliance:

1. Where the Drawings and Specifications do not comply with the minimum requirements of the Codes, either notify the Architect/Engineer, in writing during the Bidding Period, of the revisions required to meet Code requirements, or provide an installation which complies with the Code requirements. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
2. Follow Drawings and Specifications where they are superior to Code requirements.

H. Permits:

1. Obtain all permits required by authorities and agencies having jurisdiction for the work of this Division.
2. Post permits as required.

I. Tap and Connection Fees:

1. Pay fees charged by Utilities for making connections, bringing service to property line, or to meter and similar services.
2. Investment fees or plant development fees, which are charges levied by Utilities to cover the cost of the utility system to be borne by this project, are not part of the work of this Division.

J. Inspections and Tests:

1. Arrange for all required inspections and tests.
2. Pay all charges.
3. Notify Architect/Engineer 48 hours before tests.
4. Submit one copy for Owners records of permits, licenses, inspection reports and test reports.

K. LEED

1. This project will follow the guidelines and requirements of Leadership in Energy and Environmental Design (LEED). Provide all services and documentation required in this effort.

2. Commissioning: The project will have selected building systems commissioned as specified in Section 01810 – Commissioning. Coordinate pre-functional tests and start-up testing with commissioning.

1.8 RECORD DRAWINGS

A. General Recording Procedure:

1. Maintain a blue-line set of Divisions 21 through 23 Contract Drawings in clean, undamaged condition, for mark-up of installations, which vary, substantially from the Contract Drawings.
2. Record changes drawn to scale and fully dimensioned, as specified in Division 1.
   a. Work concealed behind or within other work, in an inaccessible arrangement.
   b. Mains and branches of piping systems:
      1) with valves and control devices located and numbered.
      2) with concealed unions located.
      3) with items requiring maintenance located (traps, strainers, expansion compensators, tanks, etc.).
   c. Underground piping and ducts, both exterior and interior.
   d. Ductwork layouts, including locations of coils, dampers, filters, boxes and similar units.
   e. Concealed control system devices and sensors.

B. Corrected Drawings:

1. Obtain a set of contract drawings on CAD.
2. Update the CAD files to reflect as-built conditions.
3. Transmit corrected CAD files and plots as a submittal to the Architect/Engineer for Owner's use and record.

C. Temperature Control Drawings:

1. Indicate as-built conditions of work under this contract including:
   a. Ladder wiring diagram.
   b. Pneumatic schematic diagrams.
   c. One line system diagram.
   d. Control schematic of equipment with control devices located and identified.
   e. Wiring or tubing termination diagrams.
   f. List of materials.
   g. Floor plan indicating all device locations.
   h. Control sequences.
   i. Indicate electrical power source for each point of connection to the electrical system.
2. Reproducible temperature control drawings shall be delivered to the Architect/Engineer prior to Owner's acceptance of project.

1.9 OPERATING AND MAINTENANCE DATA

A. Submission:

1. Submit typed and bound copies of Operating and Maintenance Manuals prior to scheduling systems demonstration for the Owner, as specified in Division 1.
2. Bind each Maintenance Manual in one or more vinyl covered, 3-ring binders, with pockets for folded drawings.
    a. Mark the back spine of each binder with system identification and volume number.

B. Required Contents:

1. Manuals shall have index with tab dividers for each major equipment section to facilitate locating information on specific piece of equipment.
2. Identify data within each section with drawing code numbers as they appear on Drawings and Specifications. Include as a minimum the following data:
    a. Alphabetical list of system components, with the name, address and 24 hour telephone number of the company responsible for servicing each item during the first year of operation. Include point of contact for company.
    b. Operating instructions for complete system including:
        1) Emergency procedures for fire and failure of major equipment.
        2) Major start, operation and shut-down procedures.
    c. Maintenance Instructions for each piece of equipment including:
        1) Equipment lists.
        2) Proper lubricants and lubricating instructions for each piece of equipment.
        3) Necessary cleaning, replacement and/or adjustment schedule.
        4) Product Data.
        5) Installation instructions.
        6) Parts lists.
        7) Complete wiring diagrams.
    d. Temperature control diagrams and O&M information as specified above (as-built).
    e. Marked or changed prints locating concealed parts and variations from the original system design (as-built drawings).
    f. Balancing Report.
    g. Valve schedule and associated piping schematics. See Division 23 05 53, Mechanical Identification.
    h. Copies of any extended equipment warranties, which are greater than one year.

1.10 WARRANTIES

A. The warranty period is one year after Date of Acceptance.

1. During this period, provide labor and materials as required to repair or replace defects in the mechanical system at no additional cost to the Owner. Provide certificate with O&M manual submittal which guarantees same-day service response to Owners call for all such warranty service.
2. Provide certificates for such items of equipment which have warranties in excess of one year. Insert copies in O&M manuals. Such equipment shall include:
    a. Temperature Control Valves five (5) years.
    b. Chiller compressors five (5) years.
3. Provide extended manufacturers warranties to cover one full year from date of acceptance if standard warranty starts any time prior to that date.

4. Provide factory trained service personnel for all warranty work on the DDC Control System and the following equipment:
   a. Air cooled chiller.
   b. Boilers.
   c. Condensing units.
   d. Environmental fans.
   e. Makeup air units.
   f. HVAC pumps.
   g. Heat exchangers.
   h. Rooftop units.
   i. DX ductless split systems.
   j. Unit heaters.
   k. Desiccant air handling units.
   l. Air terminal units.

1.11 SCOPE

A. The Contractor shall:

1. Supply all labor, transportation, materials, apparatus, light, and tools necessary for the completion of the mechanical work.
2. Install, maintain, and remove all construction equipment.
3. Be responsible for safe, lawful, and proper construction maintenance.
4. Construct, in the best and most workmanlike manner, a complete project and everything properly incidental thereto, as shown on the Drawings, as stated in the Specifications, or reasonably implied therefrom, all in accordance with the Contract documents.

1.12 MANDATORY GOVERNING PROVISION

A. Omissions of words or phrases, such as “the Contractor shall,” “in conformity with,” “shall be,” “as noted on the Drawings,” “according to the Drawings,” “an,” “the,” and “all,” are intentional.

B. Omitted words or phrases shall be supplied by inference.

1.13 PROTECTION OF PROPERTY AND MATERIALS

A. Provide protection against dust migration, rain, wind, storms, frost, or heat, so as to maintain all work, materials, apparatus, and fixtures free from injury or damage.

B. At end of each day’s work, cover all new work likely to be damaged.

C. Do not interrupt the integrity of the building security overnight.

D. Refer to Division 1 for additional requirements.

1.14 OWNER FURNISHED EQUIPMENT

A. All equipment called out in the Specifications or shown on the Drawings as “Owner-Furnished Equipment” shall be installed and connected under this Contract. Provide rough-ins for all

future connections indicated.

1.15 TEMPORARY FACILITIES

A. Light, Heat, Power, etc.

1. Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 1.
2. Contractor shall be responsible for maintaining the equipment in an as-new condition. Equipment will not be turned over to the Owner until it is brought up to as-new condition.
3. The contractor shall be responsible for maintaining acceptable indoor air quality in adjacent occupied spaces.

B. Use of Permanent Building Equipment for Temporary Heating or Cooling.

1. Permanent building equipment shall not be used without written permission from the Owner. If this equipment is used for temporary heating or cooling, it shall be adequately maintained per manufacturer's instructions and protected with filters, strainers, controls, reliefs, etc. The contractor shall protect all equipment and systems as directed by the engineer. The warranty period shall not start until the equipment is turned over to the Owner for his use. The contractor shall provide extended warranties for parts and labor for all such equipment. Equipment shall not be turned over to the Owner until the temperature controls have been tested and accepted by the Owner and Engineer.

1.16 INSTALLATION GENERAL REQUIREMENTS

A. Furnish, apply, install, connect, erect, clean, and condition manufactured materials and equipment as recommended in manufacturer's printed directions (maintained on job site during installation).

B. Provide all attachment devices and materials necessary to secure materials together or to other materials.

C. Make allowance for ample and normal expansion and contraction for all building components and piping systems that are subject to such.

D. Install materials only when conditions of temperature, moisture, humidity, and conditions of adjacent building components are conducive to achieving the best installation results.

E. Erect, install, and secure components in a structurally sound and appropriate manner.

F. Where necessary, temporarily brace, shore, or otherwise support members until final connections are installed.

G. Leave all temporary bracing, shoring, or other structural supports in place as long as practical for safety and to maintain proper alignment.

H. Handle materials in a manner to prevent scratching, abrading, distortion, chipping, breaking, or other disfigurement.

I. Conduct work in a manner to avoid injury or damage to previously placed work.

J. Any work so impaired or damaged shall be replaced at no expense to Owner.

K. Fabricate and install materials true to line, plumb, and level.

L. Leave finished surfaces smooth and flat, free from wrinkles, warps, scratches, dents, and other imperfections.

M. Furnish materials in longest practical lengths and largest practical sizes to avoid all unnecessary jointing.

N. Make all joints secure, tightly fitted, and as inconspicuous as possible by the best accepted practice in joinery and fabrication.

O. Consult Engineer for mounting height or position of any unit not specifically indicated or located on Drawings or specified in Specifications.

P. Job mixed multi-component materials used in the work shall be mixed in such regulated and properly sized batches that material can be used before it begins to “set”.

Q. Mixing of a partially “set” batch with another batch of fresh materials will not be accepted and entire batch shall be discarded and removed from site.

R. Clean all mixing tools and appliances that can be contaminated prior to mixing of fresh materials.

S. In addition to the above refer to each Section of the Specifications for additional installation requirements for the proper completion of all work.

PART 2 - PRODUCTS

2.1 QUALITY CONTROL

A. Refer to Division 1 of the Specifications.

B. The manufacturer of equipment or materials listed on the drawings or first named in the specification is the basis of design. If the drawings and specifications are in conflict, the drawings shall take precedence. Other manufacturers listed are considered general equivalents only. See below for coordination of substitutions.

C. Products by manufacturers not listed in this Specification may be submitted to the Engineer only during normal submittal procedure, and only as “substitutions”. All bids must use basis of design or listed general equivalents.

D. Items submitted as a substitution to the basis of design or listed general equivalents shall be identified as such and shall include a written request for substitution indicating the following:

1. Contract price adjustment.
2. Contract time adjustment.
3. Item by item breakdown of differences between basis of design and substituted item.
4. Operation, maintenance, and energy cost difference.

E. Coordination of general equivalents and substitutions: Where Contract Documents permit selection from several general equivalents, or where substitutions are authorized, coordinate clearance and other interface requirements with mechanical and other work.

1. Provide necessary additional items so that selected or substituted item operates equivalent to the basis of design and properly fits in the available space allocated for the basis of design.
2. Provide all features which are standard on the basis of design.
3. Contractor is responsible for assuring that piping, conduit, duct, flue, and other service locations for general equivalents or substitutions do not cause access, service, or operational difficulties any greater than would be encountered with the basis of design.

2.2 GENERAL SUBMITTAL REQUIREMENTS

A. Refer to Division 1.

B. Coordination and Sequencing:

1. Coordinate submittals 2 weeks (min.) prior to expected order date so that work will not be delayed by submittals.
2. No extension of time will be allowed because of failure to properly coordinate and sequence submittals.
3. Do not submit product data, or allow its use on the project until compliance with requirement of Contract Documents has been confirmed by Contractor.
4. Submittal is for information and record, unless otherwise indicated, and is not a change order request.
5. Submitting contractor is responsible for routing reviewed submittals to all parties affected including but not limited to electrical, temperature control, and test and balance subcontractors.

C. Preparation of Submittals:

1. Refer to Division 1 requirements.
2. Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, Supplier, submittal name and similar information to distinguish it from other submittals.
3. Indicate any portions of work which deviate from the Contract Documents.
   a. Explain the reasons for the deviations.
   b. Show how such deviations coordinate with interfacing portions of other work.
4. Show Contractor’s executed review and approval marking.
5. Provide space for Architect’s/Engineer’s “Action” marking.

6. Submittals which are received from sources other than through Contractor's office will be returned "Without Action".
7. Submittals shall be presented in a neat and legible fashion and shall be returned "Without Action" if presented in any other fashion.

D. Quantities: Unless otherwise indicated in Division 1, submit six copies.

1. Refer to Division 1 requirements.
2. Multiple System Items: Where a required submittal relates to an operation or item of equipment used in more than one system, increase the number of final copies as necessary to complete the Maintenance Manuals for each system.
3. Preliminary Submittal: Provide a preliminary, two-copy submittal for automatic temperature controls and when product data is required (or desired by Contractor) for selection of options by Architect/Engineer.
4. General Distribution:
    a. Provide additional distribution of submittals (not included in foregoing copy submittal requirements) to Subcontractors, Suppliers, Fabricators, Installers, Governing Authorities and others as necessary for proper performance of the work.
    b. Include such additional copies in transmittal to Architect/Engineer where required to receive "Action" marking before final distribution.
        1) Show such distributions on transmittal forms.

E. LEED Submittals:

1. Credit WE 3.1 and 3.2: Product Data for plumbing fixtures indicating water consumption. Prerequisite EA 3.0: Product Data for new HVAC equipment indicating absence of CFC refrigerants.
2. Credit EA 4.0: Product Data for new HVAC equipment indicating absence of HCFC refrigerants.
3. Credit EA 5.0: Product Data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy and water consumption performance over time.
4. Credit EQ 1.0: Product Data and Shop Drawings for carbon dioxide monitoring system and/or outdoor air monitoring station.
5. Credit EQ 3.1:
    a. Construction Indoor Air Quality (IAQ) management plan.
    b. Product Data for temporary MERV 8 filtration media.
    c. Construction Documentation: Six photographs at three different occasions during construction of the different SMACNA requirements along with a brief description of the SMACNA approach employed, documenting implementation of the IAQ management measures, such as protection of ducts, cleaning of air handling units, installation of filters, and on-site stored or installed absorptive materials.
6. Credit EQ 3.2:
    a. Signed statement describing the building air flush-out procedures including the dates when flush-out was begun and completed and statement that filtration media was replaced after flush-out.
    b. Product Data for MERV 8 filtration media used during flush-out.
    c. Report from testing and inspecting agency indicating results of IAQ testing and documentation showing conformance with IAQ testing procedures and requirements.

7. Credit EQ 4.1: Product Data for adhesives and sealants used on the interior of the building indicating VOC content of each product used. Indicate VOC content in g/L calculated according to 40 CFR 59, Subpart D (EPA method 24).
8. Credit EQ 4.2: Product Data for paints and coatings used on the interior of the building indicating chemical composition and VOC content of each product used. Indicate VOC content in g/L calculated according to 40 CFR 59, Subpart D (EPA method 24).
9. Credit EQ 5: Product Data for MERV 13 filtration media used during occupancy.
10. Credit EQ 7.1: Product Data and Shop Drawings for sensors and control system used to monitor and control room temperature.

F. Response to Submittals: Where standard product data have been submitted, it is recognized:

1. That the Submitter has determined that the products fulfill the specified requirements.
2. That the submittal is for the Architect's or Engineer's information only, but will be returned with appropriate action where observed to be not in compliance with the requirements.

G. If more than two submissions (either for shop drawings, as-built drawings, or test and balance reports) are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.

2.3 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS

A. Manufacturer's Data:

1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.
2. Delete or mark-out significant portions of pre-printed data which are not applicable.
3. Where operating ranges are shown, mark data to show portion of range required for project application.
4. For each product, include the following:
    a. Sizes
    b. Weights
    c. Speeds
    d. Capacities
    e. Piping and electrical connection sizes and locations.
    f. Statements of compliance with the required standards and regulations.
    g. Performance data.
    h. Manufacturer's specifications and installation instructions.

B. Shop Drawings:

1. Prepare Mechanical Shop Drawings, except diagrams, to accurate scale.
    a. Show clearance dimensions at critical locations.
    b. Show dimensions of spaces required for operation and maintenance.
    c. Show interfaces with other work, including structural support.

C. Test Reports:

1. Submit test reports which have been signed and dated by the firm performing the test.
2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.

D. Required equipment and shop drawing submittals:

1. Provide a submittal schedule with bid.
2. Provide equipment submittals for each item of equipment specified or scheduled in the contract documents.
3. Submittal Schedule shall show each item of equipment, applicable Section of the specifications where it is described, applicable Drawing number and schedule name where it is scheduled, date of Contractor's proposed submittal to Architect, required date to receive submittal from Architect and schedule order date.
4. Provide a Mechanical Shop Drawing Schedule for submission to the Architect with the Submittal Schedule. Refer to paragraph 1.3 -Coordination Within Divisions 21 through 23 above.

2.4 COMPATIBILITY

A. General: Provide products which are compatible with other products of the mechanical work, and with other work requiring interface with the mechanical work.

B. Altitude Ratings: Except where noted otherwise, all ratings and capacities stated in the Contract Documents are at the altitude of the project, not sea level. Project Altitude shall be considered to be 205 feet ASL.

C. Fuel Characteristics:

1. Review fuel characteristics with the Fuel Supplier designated by the Owner.
2. Determine burner or combustion equipment provisions needed for optimum performance. Provide equipment accordingly.

D. Power Characteristics:

1. For power characteristics of equipment supplied under Division 21 through 23 Sections, refer to the Sections of Divisions 26 through 28 and the Electrical Drawings for the power characteristics of each power driven item of mechanical equipment.
2. Coordinate available power with Electrical Contractor before ordering equipment. Mechanical Contractor shall be responsible for ordering equipment to meet the available power characteristics.
3. See also Division 23 05 01 of these specifications.
4. If there is a conflict between Divisions 21 through 23 documents and Divisions 26 through 28 documents, alert the engineer. Do not order equipment prior to determining the proper electrical service. No contract cost adjustment will be allowed for equipment ordered in conflict with the available power characteristics.

2.5 SAFETY PROVISIONS

A. Equipment Nameplates: Provide power-operated mechanical equipment with a permanent nameplate attached by the manufacturer, indicating:

1. The manufacturer
2. Product name
3. Model number
4. Serial number
5. Speed
6. Capacity
7. Power characteristics
8. Labels of testing, listing, or inspecting agencies
9. Other similar data

B. Where manufacturer affixed nameplate is not available, Mechanical Contractor shall fabricate and attach nameplate.

C. Guards:

1. Unless equivalent guards are provided integral with the equipment, enclose each belt drive (including sheaves) on both side in a galvanized, one inch, mesh screen of No. 18 gauge steel wire or expanded metal, fastened to an approved, structural steel frame, securely fastened to the equipment or floor.
2. Provide tachometer holes at shaft centers. Unless equivalent guards are provided integral with the equipment, install a solid guard of No. 20 gauge galvanized steel over the coupling of each item of direct-driven equipment.
3. Sides are not required on these guards except to ensure rigidity.

2.6 SAFETY PROVISIONS

A. Any refrigeration system containing CFC-11, CFC-12, HCFC-123, HCFC-22, or any of the other refrigerants listed in the Clean Air Act as a Class I or Class II Ozone Depleting Compound shall comply with the Clean Air Act and the Colorado Air Quality Control Commission Regulation #15.

B. As a minimum all systems shall be equipped with refrigerant recovery service valves, relief valves capable of resetting after activation, and for system with more than 50 pounds of charge, and isolateable receiver and/or condenser capable of holding the complete charge.

PART 3 - EXECUTION

3.1 COORDINATION OF MECHANICAL INSTALLATION

A. Inspection and Preparation:

1. Examine the work interfacing with mechanical work, and the conditions under which the work will be performed, and notify the Architect/Engineer of conditions detrimental to the proper completion of the work at original contract price.
2. Do not proceed with the work until unsatisfactory conditions have been corrected.

B. Layout:

1. Layout the mechanical work in conformity with the Contract Drawings, Coordination Drawings and other Shop Drawings, product data and similar requirements so that the entire mechanical plant will perform as an integrated system, properly interfaced with other work, recognizing that portions of the work are shown only in diagrammatic form.
2. Where coordination requirements conflict with individual system requirements, comply with the Architect's or Engineer's decision on resolution of the conflict.
3. Take necessary field measurements to determine space and connection requirements.
4. Provide sizes and shapes of equipment so the final installation conforms to the intent of the Contract Documents.

C. Integrate mechanical work in ceiling spaces with suspension system, light fixtures and other work so that required performances of each will be achieved.

3.2 PRODUCT INSTALLATION

A. Manufacturer's Instructions:

1. Except where more stringent requirements are indicated, comply with the product manufacturer's instructions and recommendations.
2. Consult with manufacturer's technical representatives, who are recognized as technical experts, for specific instructions on special project conditions.
3. If a conflict exists, notify the Architect/Engineer in writing and obtain his instruction before proceeding with the work in question.

B. Movement of Equipment:

1. Wherever possible, arrange for the movement and positioning of equipment so that enclosing partitions, walls and roofs will not be delayed or need to be removed.
2. Otherwise, advise Contractor of opening requirements to be maintained for the subsequent entry of equipment.

C. Heavy Equipment:

1. Coordinate the movement of heavy items with shoring and bracing so that the building structure will not be overloaded during the movement and installation.
2. Where mechanical products to be installed on the existing roof are too heavy to be hand-carried, do not transport across the existing roof deck; position by crane or other device so as to avoid overloading the roof deck.

D. Return Air Path: Coordinate mechanical work in return air plenum to avoid obstructing return air path.

1. Do not make changes in layout which will reduce return air path cross-sectional areas. Minimum cross-sectional area will provide an average of 500 fpm and a maximum of 750 fpm velocity through return air plenum at specified supply air quantity unless otherwise noted.

2. Provide openings in any full height walls to allow for free movement of return air. Openings are to be sized for 500-750 fpm velocity. Notify the Architect/Engineer for any openings required in fire rated walls that are not shown on the contract drawings.
3. Report any obstructions by work of other Divisions to Architect/Engineer.

E. Clearances:

1. Install piping and ductwork:
   a. Straight and true.
   b. Aligned with other work.
   c. Close to walls and overhead structure (allowing for insulation).
   d. Concealed, where possible, in occupied spaces.
   e. Out-of-the-way with maximum passageway and headroom remaining in each space.
2. Except as otherwise indicated, arrange mechanical services and overhead equipment with a minimum of:
   a. 7’0” headroom in storage spaces.
   b. 8’6” headroom in other spaces; where approved by Architect.
3. Do not obstruct windows, doors or other openings.
4. Give the right-of-way to piping systems required to slope for drainage (over other service lines and ductwork).

F. Access:

1. Provide for removal, without damage to other parts, of:
   a. Coils
   b. Humidifier manifolds
   c. Tubes
   d. Shafts
   e. Fan wheels
   f. Drives
   g. Filters
   h. Strainers
   i. Bearings
   j. Control components
   k. Other parts requiring periodic replacement or maintenance
2. Connect equipment for ease of disconnecting with minimum of interference with other work.
3. Provide unions where required.
4. Locate operating and control equipment and devices for each access.
5. Provide access panels where units are concealed by non-accessible finishes and similar work. See Section 23 05 03.
6. Extend all grease fittings to an accessible location.

3.3 PROTECTION OF WORK

A. All pipe ends, valves, ducts, and equipment left unconnected shall be capped, plugged or otherwise properly protected to prevent damage or the intrusion of foreign matter.

B. Do not allow any fans in the HVAC system to operate before the area served by the fan has been cleaned and vacuumed of all debris and dust which might enter the system.

C. Any equipment, duct or piping systems found to have been damaged or contaminated above "MILL" or "SHOP" conditions shall be replaced or cleaned to the Engineer's satisfaction.

D. Initial fill of traps:

1. Provide initial water seal fill for all waste P-traps, condensate traps, or similar traps.

3.4 PROTECTION OF POTABLE WATER SYSTEMS

A. All temporary water connections shall be made with an approved back flow preventer.

B. All hose bibs shall have as a minimum, a vacuum breaker, to prevent back flow.

C. Direct connections to hydronic systems shall only be made through a reduced pressure back flow preventer.

3.5 PROTECTION OF SYSTEMS SERVING OCCUPIED SPACES

A. Where work is being performed in occupied spaces, or occupancy is to be phased in with ongoing construction, contractor shall prevent contamination of all systems serving the occupants including but not limited to:

1. Supply Or Return Air
    a. Systems shall be capped or provided with adequate particulate and gas phase filtration to prevent dust, chemical, or biological contamination. Particulate filters shall be as a minimum equivalent to those specified for the completed system.
2. Domestic Water
    a. Isolate sterilized portions from non-sterilized portions.

3.6 REFRIGERATION SYSTEMS

A. All techniques involved in the installation of refrigeration systems shall be certified and trained in accordance with the District of Columbia Codes, and the applicable sections of the Clean Air Act.

B. No refrigerant shall be intentionally vented to the atmosphere. All refrigerant shall be recovered before opening a closed system for charging, evacuation, service or installation.

C. Refrigerants shall meet project LEED requirements.

3.7 START-UP

A. Assign a full time Divisions 21 through 23 Start-Up Coordinator to this project.

B. The Start-Up Coordinator shall develop detailed start-up procedures, equipment checkout procedures and data forms for recording compliance with contract document performance criteria,

and will assist in developing schedules for checkout and Owner acceptance.

C. The Divisions 21 through 23 Contractor shall include as part of the work of this contract, manpower, equipment, tools, ladders, instruments, etc. necessary to confirm start-up of Divisions 21 through 23 systems.

D. The Division 23 05 93, Test, Adjust and Balancing: Contractor shall include as part of the work of his/her contract, labor and material to provide manpower, equipment, tools, ladders, instruments, etc. necessary to assist the Start-Up Coordinator in accomplishing his/her work.

E. The Start-Up Coordinator shall be responsible for maintaining documentation of Start-Up activities until final acceptance of the project.

F. The documentation shall be kept current by the Start-Up Coordinator and shall be available for inspection at all times. At the time of acceptance of the project, the Start-Up Coordinator shall surrender 3 completed copies of the documentation to the Owner's representative.

G. Before Testing, Adjusting, Calibration and Balancing (Division 23 05 93), the Start-Up Coordinator shall confirm, in writing to the Owner, the following:

1. All equipment, components, and systems have been set, started-up, and adjusted.
2. Systems have been established at the appropriate temperatures and pressures for proper operation and performance.
3. All electric power connections, disconnects, fuses, circuit breakers, etc. are properly sized and installed.
4. The operation of all valves, dampers and sensors is positive (per the control sequences) and demonstrated.

H. Provide dated matrices for each item of equipment showing the date each of the start-up activities was witnessed or performed by the Start-Up Coordinator.

1. Start-up and operating performance test documentation shall include all Division 21 through 23 equipment with scheduled capacities and all Division 23 09 00 equipment.

I. At the completion of the start-up; and test and balance, Divisions 21 through 23 shall conduct a 72 hour dynamic mode demonstration of the systems in the presence of the Owner and Architect/Engineer.

3.8 DEMONSTRATION

A. Refer to Division 1 sections of the specifications regarding requirements of Record Drawings and Operation and Maintenance Manual submittal and systems demonstration.

1. Demonstrate to the Architect/Engineer that each system operates in accordance with the contract documents.
2. Explain the operation of each system to the Owner’s Representative. Explain use of O&M manual in operating and maintaining systems.

B. Date and time of demonstration will be determined by Owner.

3.9 PROJECT CLOSEOUT

A. Refer to the individual sections of the specifications for individual closeout requirements.

B. Provide all documentation required for LEED certification.

C. Provide a written schedule of when systems are to be started up, tested and demonstrated along with dates for completion of the temperature controls and balancing. This schedule shall be submitted no later than 30 days prior to starting up and testing equipment.

D. The contractor shall notify the Architect/Engineer no later than 2 weeks in advance of system testing or demonstration.

E. A check list will be used by M-E Engineers during our punch list. The contractor shall complete this to meet the requirements of the contract documents, however, this list in no way limits the contractor from other requirements of the contract documents.

3.10 LEED

A. During construction meet or exceed the recommended Control Measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 1995, Chapter 3, as summarized below:

1. HVAC Protection – Use temporary heaters whenever feasible. Seal all duct and equipment openings with plastic. If permanently installed air handlers are used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8, as determined by ASHRAE 52.2-1999, shall be used over each return air grille. Replace all filtration media immediately prior to occupancy. All leaks in ducts and air handlers should be repaired promptly.
2. Source Control – For Contractor information, all paints, carpet, caulks, adhesives, sealants are specified as low-VOC and non-toxic. Recover, isolate and ventilate containers housing toxic materials. Avoid exhaust fumes from idling vehicles and gasoline fueled tools.
3. Pathway Interruption – During construction, isolate areas of work to prevent contamination of clean or spaces. Ventilate using 100% outside air to exhaust contaminated air directly to the outside during installation of VOC emitting materials. Use pressure differentials or barriers between work and clean areas to prevent contaminated air from entering clean areas.
4. Housekeeping – Protect building materials from weather and store in a clean area prior to unpacking for installation. Clean all coils, air filters, and fans before performing testing and balancing procedures. Institute cleaning activities designed to control contaminants in building spaces.
5. Scheduling – Complete applications of wet and odorous materials such as VOCs in paints, sealants, and coatings before installing absorbing materials such as ceiling tiles, carpets, insulation, gypsum products, and fabric-covered furnishings. Avoid exposure of all interior materials to moisture.
6. Protect stored on-site or installed absorptive materials from moisture damage.

B. After construction ends, prior to occupancy and with all interior finishes installed, perform a building flush-out by supplying a total air volume of 14,000 cu.ft. of outdoor air per sq.ft. of

floor area while maintaining an internal temperature of at least 60 degrees F and relative humidity no higher than 60%.

1. Contractors option: Either full continuous flush-out or air contaminant testing is required, not both,
2. For building flushout, perform building flush-out before occupancy and after construction is compete, HVAC systems have been tested, adjusted, and balanced, and new filtration media has been installed. Perform a building flush-out by supplying a total air volume of 14,000 cu.ft. of outdoor air per sq.ft. of floor area while maintaining an internal temperature of at least 60 degrees F and relative humidity no higher than 60%. If interior spaces must be occupied prior to completion of the flush-out, supply a minimum of 25% of the total air volume prior to occupancy and provide minimum outside air volumes of 0.30 cfm per square foot or design minimum outside air rate, whichever is greater. Install new HVAC filtration media after completion of flush-out and before occupancy or further testing. OR
3. For Air Contaminant testing, perform air contaminant testing prior to occupancy, after interior finishes are installed, HVAC system has been tested, adjusted, and balanced, and new HVAC filtration media has been installed. Collect indoor air samples representative of occupied areas. Collect samples at outside air intake of each air handler at the same time as indoor samples are taken. Analyze air samples and submit report. If air samples show concentrations higher than those specified, ventilate with 100% outside air and retest, or conduct full building flushout as specified above.
4. Air Contaminant Concentration Determination and Limits:
    a. Carbon monoxide: not more than 9 ppm and not more than 2 ppm higher than outdoor air.
    b. Formaldehyde: Not more than 50 ppb and not more than 20 micrograms per cubic meter higher than outside air.
    c. Total Volatile Organic Compounds: Not more than 500 micrograms per cubic meter and not more than 200 micrograms per cubic meter higher than outside air.
    d. 4-Phenylcyclohexene: Not more than 6.5 micrograms per cubic meter.
    e. Particulates: Not more than 50 micrograms per cubic meter.
    f. Total Particulates: Not more than 20 micrograms per cubic meter higher than outside air

C. Construction waste management: Manage construction waste in accordance with provisions of Division 1. Submit documentation to satisfy the requirements of that section.

END OF SECTION 230502

SECTION 23 0503 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements.

B. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. The Architect design team shall decide which is more stringent.

C. Provisions of this Section shall also apply to all Sections of Divisions 21 through 23.

1.2 SUBMITTALS

A. Manufacturer's Data - Submit manufacturer's data for:

1. Access panels.
2. Fire stopping materials.
3. Heat Trace.

B. Application Data - Submit application data for firestopping materials showing UL required installation details for every combination of pipe material, penetrated structure, opening size and required fire rating within the scope of this project. Application data drawings shall include UL system number.

C. LEED:

1. Adhesives and Sealants:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standard: South Coast Air Quality Management District (SCAQMD) Rule #1168, July 1, 2005 and Green Seal Standard for Commercial Adhesives GS-36, October 19, 2000.
2. Low-Emitting Paints and Coatings:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standards: Green Seal Standard GS-11, Paints, First Edition, May 20, 1993; Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997; South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, January 1, 2004.

PART 2 - PRODUCTS

2.1 ACCESS PANELS

A. See Division 8 for access panel types and finishes.

1. If panels are not specified in Division 8, comply with the following:
   a. Manufacturers:
      1) Design Basis: Milcor Division, Inryco, Inc.
      2) Other Acceptable Manufacturers:
         a) Birmingham Ornamental Iron Co.
         b) Karp Associates, Inc.
         c) Wilkenson Co., Inc.
         d) Zurn.

B. Construction:

1. Doors: 14 gauge steel.
2. Frames: 16 gauge steel.
3. Fire Rating: Equivalent to construction in which installed.
4. Latches: Flush or concealed, ¼ turn.
5. Finish: Compatible with finish of construction in which installed.

2.2 FIRE STOPPING MATERIAL

A. Manufacturers:

1. Design Basis: 3M.
2. Other acceptable manufacturers:
   a. GE
   b. Metalines
   c. Hilti

B. General Requirements:

1. Products to be used shall have been tested in accordance with ASTM E 814-88, and be listed in the UL Fire Resistance Directory.

C. Bare Piping:

1. Model: FD 150, or CP-25.

D. Insulated Piping:

1. Model: CP-25 or FS-195, Intumescent.
2. “No-sag” or “self-leveling” as required.

E. Plastic Piping:

1. Model: CP-25 or FS-195, Intumescent.

2. "No sag" or "self-leveling" as required.

F. Accessories:

1. Provide fasteners, restricting collars, backing materials, and protective coatings as required to comply with the UL system listing.

2.3 ACOUSTICAL/PRESSURE SEALING MATERIAL

A. Manufacturers:

1. Design Basis: D.A.P. – Mono Acoustical Sealant
2. Other acceptable manufacturers:
   a. GE
   b. Metalines
   c. Hilti
   d. Pecora
   e. Tremco
   f. U.S.G.

B. General Requirements:

1. Non-skinning, non-hardening synthetic butyl rubber.
2. Effective adhesive seal for air and vapor barrier.
3. Acceptable for use in air plenums.

C. Accessories:

1. Provide fasteners and backing rods as recommended by manufacturer.

2.4 HEAT TRACE

A. Manufacturers:

1. Design Basis: Raychem.
   a. Model: XL-Trace for freeze protection applied between pipe and insulation.
   b. Model: Ice stop for freeze protection applied inside storm drain leaders and down spouts.
2. Other acceptable manufacturers:
   a. Thermon
   b. Hevi-Duty/Nelson

B. Features:

1. Self regulating at all points along its length.
2. 90% power reduction from 40ºF pipe temperature to 150º pipe temperature.
3. No overheating if crossed.
4. Provide outer jacket and braided copper shield for use inside roof drain leaders or on piping without a ground path.

C. Accessories:

1. Provide tee, splice, and end seal kits as required by the manufacturer.
2. Provide ambient sensing thermostat in a NEMA 4x enclosure, with three (3) contacts rated at 22 amps each.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Quality Coordination: Where excavation and backfill for mechanical work passes through or occurs in the same area as work specified in Division 2, comply with both the requirements of Division 2 and the requirements of this Section, or whichever is the more stringent (as determined by the Architect/Engineer in cases of conflicting requirements).

B. Inspection:

1. Examine the areas to be excavated, and the conditions under which the work is to be performed.
2. Notify the Architect/Engineer in writing of conditions detrimental to the proper completion of the work.
3. Do not proceed with excavating until unsatisfactory conditions have been corrected.

C. General:

1. Do not excavate for mechanical work until the work is ready to proceed without delay, so that the total time lapse from excavation to completion of backfilling will be minimum.
2. Remove all rock and boulders from excavation before installing mechanical work.
3. Slope sides of excavations as required for stability, or provide necessary shoring.
4. Remove shoring during backfilling.
5. Excavate near large trees (within the drip line) by hand.
    a. Protect the root system from damage or drying to the greatest extent possible.
    b. Maintain moist condition for root system and cover exposed roots with burlap.
    c. Paint root cuts of 1” diameter and larger with asphaltic tree paint.
6. Saw-cut asphalt and concrete surfaces.

D. Existing Utilities: Locate and protect existing utilities and other underground work in a manner which will ensure that no damage or service interruption will result from excavating and backfilling.

E. Depth of Excavation:

1. Depth for Exterior Piping: Except as otherwise indicated, excavate for exterior piping so that the vertical distance between top of piping and finished grade will not be less than that prescribed by code.
2. Excavate for exterior water-bearing piping (water, steam condensate, drainage) so that the vertical distance between top of piping and finished grade will not be less than 5’0” vertical distance below finished grade.
3. Depth for Unsatisfactory Soil Conditions:

a. Where directed, because of unsatisfactory soil condition at bottom of excavation, excavate additional depth as directed to reach satisfactory soil-bearing condition. Backfill with "squeegee" washed rock, or other approved sub-base material, compacted as directed, to indicated excavation depth.
b. Where piping crosses over an area more than 5'0" wide, which has been previously excavated to a greater depth than required for the piping installation:
   1) Excavate to undisturbed soil in a width equal to the pipe diameter plus 2'0".
   2) Install "squeege" washed rock, or 8" courses of approved subbase material; each course compacted to 95% of maximum density, as required to fill excavation and support piping.
c. Refer to Change Order procedure elsewhere in Contract Documents.

F. Protection:

1. Provide temporary covering or enclosure and temporary heat as necessary to protect bottoms of excavations from freezing and frost action. Do not install mechanical work on frozen excavation bases or subbases.
2. Coordinate excavations with weather conditions, to minimize the possibility of washouts, settlements and other damages and hazards.
3. Allow no more than 100 feet between pipe laying and point of complete backfilling.
4. Maintain dry excavations for mechanical work by removing water.
   a. Protect excavations from inflow of surface water.
   b. Pump minor inflow of ground water from excavations.
   c. Protect excavations from major inflow of ground water by installing temporary sheeting and waterproofing.
   d. Provide adequate barriers which will protect other excavations and below-grade property from being damaged by water, sediment or erosion from or through mechanical work excavations.
5. Provide signs, illumination and barricades as necessary to prevent accidents at excavations.
6. Install and operate a well-point dewatering system to maintain ground water at a level approximately 2'0" below mechanical work excavations, until backfilling is completed.

G. Excavated Material:

1. Store excavated material (temporarily) near the excavation, in a manner which will not interfere with or damage the excavation or other work. Do not store under trees (within the drip line).
2. Retain excavated material which complies with the requirements for backfill material.
3. Remove excavated material which is either in excess of quantity needed for backfilling or does not comply with requirements for backfill material from project site, and dispose of in a lawful manner.
4. Coordinate acceptable stockpiling areas with Owner in advance of excavation.

H. Bedding:

1. Where indicated below, install as bedding material graded sand with 100% passing through a 3/8" sieve, and 0% passing through No. 100 sieve.
   a. Compact by tamping to form a firm base for the work.

b. Install bedding from six inches below bottom of pipe to six inches above top of pipe.
c. Provide bedding for:
1) Wrapped, coated or plastic pipe and tanks.
2) Piping over six inches, horizontal cylindrical tanks, and similar work.
a) Shape the subbase to fit the shape of the bottom 90º of the cylinder, for uniform continuous support.
3) All water and sewer pipe.

2. Where rock is used as sub-base, place 8-mil polyethylene between rock and bedding.
3. Shape sub-bases and bottoms of excavations with recesses to receive pipe bells, flange connection, valves and similar enlargements in the piping systems.

I. Concrete Encasement: Where piping under roadways is less than 2'6" below surface of roadway, or where ductwork is buried below grade:

1. Provide 4" base slab of concrete to support piping and ductwork.
2. After piping or ductwork is installed and tested, provide 4" thick encasement (sides and top) of concrete before backfilling.
a. Provide external structural reinforcing of all rectilinear cross section ductwork or any ductwork which is less than 18 ga sheet metal (or equivalent) to prevent collapse of ductwork encasement.
3. Provide minimum 2500 psi concrete for encasement and slab.

J. Backfilling:

1. Do not backfill until installed mechanical work has been tested and accepted, wherever testing is indicated.
2. Condition backfill material by either drying or adding water uniformly, to whatever extent may be necessary to facilitate compaction to the required densities.
3. Do not backfill with frozen soil materials.
4. Backfill simultaneously on opposite sides of mechanical work, and compact simultaneously.
5. Do not dislocate the work from installed positions.
6. Backfill to elevations matching adjacent grades, at the time of backfilling excavations for mechanical work.
7. Backfill with finely graded sub-base material to 6" above wrapped, coated, and plastic piping and tanks, and to centerline of other tanks.
8. Backfill excavations in 8" high courses of backfill material, uniformly compacted to the densities indicated in Division 2 using power-driven, hand-operated compaction equipment.
9. If densities are not indicated in Division 2, compact to the following percent of maximum per ASTM D1557:
a. Lawn/Landscaped Areas: 85%.
b. Paved Areas, Other than Roadways: 90%.
c. Roadways: 95%.
d. Floors: 95%.
10. Where compaction tests indicate lower densities of backfill than specified, continue compaction (and re-excavation and backfilling where necessary).
a. Provide additional testing as directed by the Architect/Engineer.

b. The allowable density tolerance is not more than one-test-out-of-five failing more than two percentage points below the specified density.
c. Initial testing is not work of this Section.

11. Where subsidence is measurable or observable at mechanical work excavations during the guarantee period:
    a. Remove the surface (pavement, lawn or other finish).
    b. Add backfill material, compact, and replace the surface treatment.
    c. Restore the appearance, quality and condition of the surface or finish to match adjacent work.
    d. Eliminate evidence of the restoration to the greatest extent possible.

K. Landscape Restoration:

1. Where excavation and backfill for mechanical work passes through or occurs in a landscaped area, repair or replace the landscape work to match the original condition and quality of the work.
2. Comply with the requirements of Division 2 for repair or replacement of work, and for follow-up maintenance on lawns and planting to ensure satisfactory recovery.

L. Pavement Restoration:

1. Where excavation and backfill for mechanical work passes through or occurs in an area of paving or flooring, replace and restore the construction and finish of the paving or flooring to match the original condition and quality of the work.

M. Surface Repairs:

1. The repairing and replacing of previously installed landscape development work, paving, floor slabs and similar finishes occurring in excavated areas shall be provided, but is not included in work of Divisions 21 through 23.

3.2 CUTTING AND PATCHING

A. Refer to Division 1 of the Specifications.

B. General: Provide measurements, drawings and layouts to installers of other work so that required openings may be provided as construction progresses. Any cutting and patching made necessary by failure to provide this information shall be done at no increase in the contract amount.

C. General: All cutting and patching of existing work required for work of Divisions 21 through 23 is included in Divisions 21 through 23. Cutting and patching is not work of Divisions 21 through 23, except as provided in Article 3.2 A. of this Section.

D. Where possible, mark openings to be cut on existing construction. Otherwise, provide measurements, drawings and layouts to the trade doing the cutting so that openings may be provided as construction progresses.

E. Cutting Concrete:

1. Where authorized, cut openings through concrete for pipe penetration and similar services by core drilling or sawing.
2. Do not cut by hammer-driven chisel or drill.

F. Cutting:

1. Cut openings in accordance with layouts, measurements or drawings of the Installer of work requiring openings. Cut openings in concrete by core drilling or sawing; not by hammer-driven chisel or drill.
2. Coordinate the location of all openings with structural drawings. Report any discrepancies to Architect. Do not proceed with work until discrepancies have been resolved.
3. Do not endanger or damage other work through the procedures and processes of cutting to accommodate mechanical work.
4. Review the proposed cutting with the Installer of the work to be cut, and comply with his recommendations to minimize damage.
5. Where necessary, engage the original Installer or other specialists to execute the cutting in the recommended manner.

G. Patching:

1. Where patching is required to restore other work because of either cutting or other damage inflicted during the installation of mechanical work, engage experienced craftsmen to complete the patching of the other work.
2. Restore the other work in every respect, including the elimination of visual defects in exposed finishes.
3. All openings in fire rated construction shall be patched and sealed with U.L. approved sealant to maintain the fire integrity of the structure.

H. Perform cutting, and patching required to:

1. Uncover work to provide 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. Remove samples of installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineers observation of concealed work.

I. Painting: Paint all surfaces marred by cutting and/or patching to match existing.

1. Engage experienced painters.
2. Comply with requirements of Painting Sections of this Specification.

J. Structural Limitations:

1. Do not cut or drill into structural framing, walls, floors, decks, and other members intended to withstand stress, except with Engineer’s written authorization.
    a. Provide lintels, columns, braces and other temporary and permanent supports made by cutting.

b. Submit shop drawings of permanent supports.
c. Do not penetrate legs of structural "T's" or any other location where pre-stressed structural chords are likely to be encountered when cutting or drilling.

3.3 ACCESS PANELS

A. Furnish access panels where indicated and at locations where required for access to:

1. Concealed valves
2. Dampers
3. Control devices
4. Equipment servicing
5. Shock arresters
6. Air vents
7. Flow measuring and balancing stations
8. Any other device or item equipment requiring maintenance, adjustment or service.

B. Deliver access panels for installation by the trade responsible for surface in which installed.

1. Provide instructions for location.
2. Access doors shall be sized as required to allow equipment removal, with a minimum size of 12"x12".

3.4 SLEEVES

A. Provide sleeves for piping passing through walls, floors and roofs.

B. Set pipe sleeves and inserts in place before concrete is poured. Coordinate the placing of these items to avoid delaying concrete placing operations.

C. Locate chases, shafts, and openings required for the installation of the mechanical work during framing of the structure. Do any additional cutting and boring required due to improperly located or omitted openings without cost to the Owner under the supervision of the Owner's representative.

D. Size sleeves for below grade pipe a minimum of 2" beyond outside of pipe.

E. Coat surface of all sleeves in contact with concrete, masonry or soil with two coats of coal tar bitumastic paint.

F. Provide Sleeves as Follows:

Sleeve Location	**Sleeve Material**
Interior Stud Partition Walls	Adjustable galvanized sheet metal with wall flanges and plaster lip, 2" and smaller – 22 gauge, 3" through 6" – 20 gauge, 8" and larger – 18 gauge.
Membrane Waterproof Floor and Roof Construction	Galvanized cast iron body with flashing clamp, threaded for sleeve riser. (J.R. Smith 1760 or equivalent by Ancon, Zurn or Josam).

Sleeve Location	**Sleeve Material**
Nonmembrane Floor, Construction	Non-adjustable galvanized sheet metal with deck flange and end cap, 2" and smaller – 22 gauge, 3" – 20 gauge, 4" and larger – 16 gauge.
Exterior Walls Below Grade	Standard weight galvanized steel pipe with a continuously welded water stop of ¼" steel plate extending from outside of sleeve a minimum of 2" all around. Provide modular mechanical–type seal consisting of interlocking synthetic rubber links with bolts shaped to continuously fill the annular space between the pipe and sleeve. Thunderline Corporation "Link-Seal" sealant assembly or equal by Metraflex "MetaSeal".
Floors of Mechanical Rooms, Concrete Walls or Masonry Walls Above Grade.	Standard weight galvanized steel pipe.

G. Length of Sleeves as Follows:

Location	**Sleeve Length**
Floors	Equal to depth of floor construction including finish. Extend minimum of 1" above finished floor level within partitions, mechanical rooms, pipe chases and finished areas.
Roofs	Equal to depth of roof construction including insulation.
Walls	Equal to depth of construction.

3.5 FIRE STOPPING

A. Install firestopping materials in accordance with their UL and ASTM tested methods.

B. Coordinate required annular space with size of pipe and sleeve. Refer to Section 23 05 22.

C. Requirements for specific systems:

1. Cold piping - includes chilled water, domestic water, storm water and refrigerant: Insulation and vapor barrier shall be continued through wall and firestopping for "insulated piping" shall be provided.
2. Hot piping - to 250ºF -includes domestic hot water, steam to 15 psig and heating hot water: The Contractor has the option of continuing the insulation through the penetration and providing firestopping for "insulated piping", or stopping the insulation on either side of the penetration and using firestopping for "uninsulated piping".
3. High temperature piping, over 250ºF or over 15 psig steam: Contractor shall stop insulation and provide firestopping for "high temperature piping".

3.6 HEAT TRACE

A. Heat trace cable shall be installed by a licensed electrician.

B. Apply the heat trace cable on the pipe after pressure testing.

1. Do not spiral wrap on pipe.
2. Make one wrap at valves.
3. Secure to pipe with methods approved by manufacturer.

C. Apply “Electrically Traced” signs on outside of insulation.

D. Test with a 1000 VDC meager minimum resistance 20 mega ohms.

E. Heat trace shall be sized as follows, based on - 20ºF ambient, to maintain 40ºF pipe temperature:

PIPE SIZE	**1” INSULATION**	**2” INSULATION**
Less than 2”	3 w/ft.	3 w/ft
2”, 2½”, 3”	5 w/ft	3 w/ft
4”, 5”, 6”	8 w/ft	5 w/ft
8”, 10”, 12”	(2 cable circuits) 8 w/ft ea.	8 w/ft

3.7 EQUIPMENT BASES AND SUPPORTS

A. Supporting Steel: Provide supporting steel not indicated on the Structural Drawings for equipment, pipe, ductwork, and other pieces of this Division’s work requiring same.

1. Submit shop drawings and structural calculations to the Engineer for information and records.
2. Brace and fasten with flanges bolted to structure.
3. Paint supporting steel with one coat of primer paint in the shop after fabrication welding is complete. Paint completed field joints with one coat of matching primer.

B. Housekeeping Bases:

1. Concrete bases for pumps, boilers, tanks, fans, etc., including anchor bolts and inserts, will be provided in accordance with American Concrete Institute (ACI) and American Society for Testing and Materials (ASTM) Standards for housekeeping pads and equipment support bases.
2. The concrete shall be placed in accordance with setting diagrams and sizes furnished by the equipment installer.

3.8 DRIP PANS

A. Drip Pans: Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical (or electronic) work which is sensitive to moisture. Otherwise, provide drip pans under mechanical piping, sufficient to protect electrical work from dripping.

1. Locate pan immediately below piping, and extend a minimum of 6” on each side of piping and lengthwise 18” beyond equipment being protected.
2. Fabricate pans 2” deep of reinforced sheet metal with rolled edges and soldered or welded seams; 22 gauge galvanized steel.
3. Provide ¾” copper drainage piping from pan to nearest floor drain or similar suitable point of discharge, and terminate pipe as an open-sight drainage connection.

4. Provide permanent support and anchorage to prevent displacement of drip pans.
5. Insulate bottom of pan as directed by Engineer.

3.9 LEED

A. Construction Indoor Air Quality Management: Manage indoor air quality in accordance with provisions of Section 01352.

B. Construction Waste Management and Disposal: Manage construction waste in accordance with provisions of Section 01524.

C. Paints and coatings must comply with Green Seal Standard GS-11, Green Seal Standard GC-03, and South Coast Air Quality Management District Rule 1113.

END OF SECTION 230503

SECTION 23 0513 - MOTORS AND STARTERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data.

1. Motors: Identify by unit served. Include:
   a. Voltage
   b. Phase
   c. Horsepower
   d. Frame
   e. Insulating class
   f. Efficiency
   g. Power factor
   h. Index number
   i. Speed
   j. Starting characteristics
2. Starters: Identify by motor served. Include:
   a. Enclosure, NEMA Type
   b. NEMA size
   c. Accessories, switches, transformers, etc.
   d. Wiring diagram
   e. Auxiliary contacts
   f. Thermal overload size
3. Submit as part of packaged unit submittals when purchased as part of item of equipment.

1.2 SINGLE MANUFACTURER

A. Provide all motors, except those factory mounted, by a single manufacturer.

B. Provide all starters, except those factory mounted, by a single manufacturer.

C. "Factory mounted" means "as part of a packaged unit" where the motor is not purchased separately from the driven equipment.

PART 2 - PRODUCTS

2.1 MOTORS (OTHER THAN FACTORY MOUNTED)

A. Manufacturers:

1. Design Basis: Century
2. Other Acceptable Manufacturers:
   a. General Electric
   b. Westinghouse

c. U.S. Motor
d. Allis Chalmers
e. Louis Allis

3. Factory mounted motors may be by equipment manufacturer's standard supplier.

B. Bearings: Ball bearings, grease lubricated with grease fittings.

C. Enclosure: As required by location.

D. Service Factor: 1.15.

E. Full-Load Operation: At 105ºF and altitude of project.

F. Insulation:

1. Constant Speed: Class B.
2. Variable Frequency Controlled: Class F.

G. Efficiency Ratings:

1. All motors one horsepower and larger, except as noted, shall be premium efficiency motors, in accordance with NEMA Standard MGI-2003, Tables 12-12 and 12-13.

H. Electrical Characteristics:

1. Refer to sections 230501, Mechanical and Electrical Coordination.
2. Motors ½ hp and smaller shall be 115-volt single phase.
3. Motors ¾ hp and larger shall be three phase, of voltage shown in Electrical Section of Contract Documents.

I. Multi-speed Motors:

1. Type: Motors may be one of the following:
   a. Two speed, two winding 1800/900 rpm.
   b. Two speed, one winding 1800/900 rpm.

J. Variable Speed Drives:

1. All motors operated by a variable speed drive shall be rated for inverter duty.
2. Motor insulation shall be rated for 1200-volt peak.
3. Provide shaft grounding Aegis SGR or equal on motors to be used with variable speed drives.

2.2 MOTORS (FACTORY MOUNTED)

A. Provide premium efficiency motors.

B. Variable Speed Drives:

1. All motors operated by a variable speed drive shall be rated for inverter duty.

2. Motor insulation shall have 1200 volt peak capacity.
3. Provide shaft grounding or insulated bearings on motors to be used with variable speed drives.

2.3 STARTERS

A. Manufacturers:

1. Allen Bradley
2. Cutler-Hammer
3. General Electric
4. Square D
5. Cerus

B. General:

1. Starters shall be standard NEMA sizes and UL listed.

C. Type: Across the line except where noted.

D. Enclosure: NEMA Type as required for location.

E. Overload Protection:

1. Type: Trip-free thermal overload relay.
2. Location: Each ungrounded conductor.
3. Reset: Manual.
4. Ambient Temperature Compensation: Provide where required.
5. Overload protection to be sized for nameplate running amps.

F. Auxiliary Contacts:

1. Provisions to add three without removing starter from enclosure.
2. Number: Provide up to three per starter as required for control sequence, and one (1) auxiliary contact.
3. Switchable type, easily changed from N.O. to N.C. without removing from its mounting.

G. Switches in Cover:

1. Manually Controlled: Three wire start-stop.
2. Automatically Controlled: Hand-off-automatic.
3. Start and stop indicating lights.
4. Equipment used for life safety (smoke exhaust, etc.): Hand-Automatic.
5. Equipment not designed to run continuously: Off-Automatic.

H. Control Transformer:

1. Provide when line voltage exceeds 208 volts.
2. Secondary wiring shall have one leg fused and the other grounded.

3. Secondary voltage not to exceed 120 volts.

I. Provide starters for all motors as follows:

1. Single phase motors less than ½ hp.
   a. With internal overload protection: None.
   b. Without internal overload protection:
      1) Manually Controlled: Manual starter.
      2) Automatically Controlled: Magnetic starter.
2. Single phase motors ½ hp and larger:
   a. Manually Controlled: Manual starter.
   b. Automatically Controlled: Magnetic starter.
3. Three Phase Motors: Magnetic starter.

J. Soft Start Starters:

1. Provide Y-Delta or solid state reduced voltage starters for all motors 50hp and larger.
2. Starter shall limit starting voltage to 200% of full load voltage.

K. Multi-Speed Starters:

1. Starters shall be suitable for the type multi-speed motor selected.
2. Provide time delay for automatic transfer from high to low speed.

L. Housing coils to be 120V.

M. Motor Protection: (above 20 hp)

1. Provide Single-phase protection.
2. Provide under-voltage protection.

PART 3 - EXECUTION

3.1 MOTORS

A. Install motors on motor mounting systems so coupling or belt drive is properly aligned. Provide proper belt tension. Dowel direct coupled motors.

3.2 STARTERS

A. Deliver to installer of electrical work.

B. All safety devices shall be wired so that they will stop the motor with a hand-off-automatic switch in the hand as well as the automatic position.

END OF SECTION 230513

SECTION 23 0521 - PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Welder Qualifications: Welders, both on-site and off-site, shall be certified for the type of work being performed by one of the following:

1. National Certified Pipe Welding Bureau.
2. Intermountain Testing Company

B. Welder Certificates:

1. Submit one copy of certificate to Architect/Engineer.
2. Maintain one copy on project site.

C. LEED:

1. Adhesives and Sealants:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standard: South Coast Air Quality Management District (SCAQMD) Rule #1168, July 1, 2005 and Green Seal Standard for Commercial Adhesives GS-36, October 19, 2000.
2. Low-Emitting Paints and Coatings:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standards: Green Seal Standard GS-11, Paints, First Edition, May 20, 1993; Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997; South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, January 1, 2004.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Refer to the following sections:

1. 21 10 00 - Fire Protection
2. 22 10 00 - Plumbing Piping
3. 22 15 00 - Compressed Air Systems
4. 22 60 00 - Medical Gas Systems
5. 22 62 00 - Vacuum Systems
6. 22 21 23 - Natural Gas Piping
7. 23 21 13 - Hydronic Piping
8. 23 22 13 - Steam and Condensate Piping

9. 23 23 00 - Refrigerant Piping
10. 22 21 13 - Fuel Oil System
11. Other Divisions 21 through 23 sections after specific system requirements.

2.2 GROOVED PIPE COUPLING SYSTEMS

A. Manufacturers of Coupling System:

1. Basis of Design: Victaulic
2. Other Acceptable Manufacturers: Grinnell and Gruvlok. Alternate is to provide a system of standard weight black steel pipe with black steel standard weight butt weld or 125 lb. cast iron flanged fittings.
3. All couplings, gaskets and joining method adapters shall be provided by one manufacturer.
4. Training: A factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation.

B. Dimensional Standards:

1. All grooved pipe fittings, couplings, and specialties shall conform to standard dimensional standards ANSI/ANWA C-606 or MIL-P-11087C.

C. Acceptable Products:

1. Only the following grooved pipe products may be used:
   a. **Gaskets:** (ASTM D2000) EHP, for water service, with or without propylene glycol -30ºF to 250ºF, primary seal by compression of coupling housing, either pressure or vacuum shall assist in sealing force.
   b. **Couplings - Steel Pipe:** Ductile iron (ASTM A-536) or malleable iron (ASTM A-47), with enamel paint coating.
      1) Rigid Couplings: Style 107, 07, W07 zero flex.
      2) Flexible Couplings: Style 177, 77, W77.
   c. **Flange Adapters:** Same materials as couplings. Provide for rigid connection to grooved pipe. Provide flange washers and/or flange gaskets as required for mating to non-standard flanges, such as butterfly valves with elastomeric face, or serrated face flanges.
      1) ANSI Class 125 or 150: Style 741.
      2) ANSI Class 300: Style 743.
      3) Alternate to flange adapter: Flange by groove nipple #41 (Class 125), #45 (Class 150), #16 (Class 300).
   d. **Branch Outlet Couplings:** Design similar to coupling with integral side outlet.
   e. **Fittings for steel pipe:** Standard pattern fittings, ductile iron (ASTM A-536), malleable iron (ASTM A-47) or segmentally welded Schedule 40 steel (ASTM A-53) with enamel paint coating. All changes in direction greater than 22º shall be with R=1.5D radius elbow. All branches and changes in direction in drainage piping shall be made with sanitary type lateral branches and R=1.5D elbows.
   f. **Accessories:** Other piping accessories such as strainers, suction diffusers and flow indicators may be provided with grooved ends, all such accessories shall comply with the applicable specification section.

2. All other pipe products shall conform to the requirements of other Divisions 21 through 23 sections. Acceptance of grooved pipe systems does not imply acceptance of the coupling manufactures valves, branch outlets, strainers, or other specialties.

2.3 PRESS FIT JOINING SYSTEM

A. Manufacturer

1. Viega ProPress
2. Other approved manufacturer

B. Material

1. Press Fittings: Copper press fittings. Must comply with ASME B16.18 or B16.22.
2. O-Rings: EPDM
3. Fittings shall be rated for 0°F to 250°F, and 250 psi.

C. Application

1. Domestic Water, 4” and smaller
2. Hydronic Systems, 4” and smaller

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. General:

1. Install pipe, tube and fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure.
2. Install each run with a minimum of joints and couplings, but with adequate and accessible unions for disassembly, maintenance or replacement of valves and equipment.
3. Reduce sizes by use of reducing fittings.
4. Install piping without springing or forcing.
5. Provide sufficient swing joints, anchors, expansion loops and devices necessary to permit free expansion and contraction without causing undue stresses.
6. Support piping independently at equipment so its weight will not be supported by the equipment.
7. Support piping to maintain a consistent slope as indicated on the drawings without sagging or pocketing of any kind. Where not otherwise indicated, all horizontal piping shall slope a minimum of 1/16 inch per foot to drain at system low points.
8. Provide manual air vents at high points of all pumped piping systems. Provide drains at all low points.
9. Install horizontal piping parallel to building construction, make any changes in direction with fittings.

B. Location:

1. Locate piping runs, except as otherwise indicated, both vertically and horizontally to allow for complete drainage of piping system (pitched to drain).
    a. Avoid diagonal runs wherever possible.
    b. Orient horizontal runs parallel with walls and column lines.
2. Hold piping close to walls, overhead construction, columns and other structural and permanent-enclosure elements of the building.
    a. Limit clearance to 0.5” where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any.
    b. Where possible, locate insulated piping for 1.0” clearance outside insulation.
3. Wherever possible in finished and occupied spaces, conceal piping from view by locating in column enclosures, in hollow wall construction or above suspended ceilings.
    a. Do not encase horizontal runs in solid partitions, except as otherwise indicated.

C. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures.

1. Exception: where shown on drawings or where accepted by the Engineer, provide drip pan under piping, and conform to NEC.
2. In no case shall piping run directly above transformers, electrical panels or switchgear.

D. Dielectric Unions: Install dielectric unions to prevent galvanic action between ferrous and non-ferrous piping.

1. Install in an accessible location or provide access doors.

3.2 PLASTIC PIPE

A. Use:

1. Contractor shall take full responsibility that the plastic piping used and its installation meets with the approval of the local authorities.
2. Pipe shall be insulated in air plenums such that the entire installation meets ASTM E84 (NFPA 25) with regard to flame spread and smoke developed ratings suitable for plenum installation.
3. Provide pipe with U.V. inhibitors or paint (under Division 9):
    a. For all plastic pipe exposed to sunlight or installed in exterior, exposed locations.
    b. Store PVC without inhibitors indoors.

3.3 WELDING

A. Welding:

1. Conform to Code for Pressure Piping ANSI B31.
2. Machine cut and bevel piping ends for v-type joints.
3. Use recommended bevels and spacing between ends of pipe to assure full penetration complete to inside diameter of pipe.

B. Welded Joints:

1. Will be observed visually by the Architect/Engineer.

2. Any weld judged defective from a visual observation, shall be ordered tested at the expense of the Contractor or chipped out for full depth and re-welded.

C. Welding Fittings:

1. Unless otherwise noted, make all changes in direction and branch take offs with manufactured fittings.
   a. Use long radius (R=1.50) fittings wherever possible.
2. Shop Fabricated Fittings:
   a. Branches more than two pipe sizes smaller than main line may be made with "weld-o-let" type pre-manufactured saddle fittings.
   b. Where specifically allowed by the Engineer, angles of less than 22½º and branch piping from headers may be made by shop fabricated or manufactured metered fittings.
   c. Submit shop drawings.
   d. Thoroughly clean fittings to remove slag.
   e. Fittings shall be available for observation by the engineer prior to installation.
3. In no case will field made miters or weld-o-let fittings be allowed. Exception: Temperature control wells and water treatment taps may be made with weld-o-let fittings in pipe 3" or larger in diameter.

3.4 COPPER TUBING JOINTS AND FITTINGS

A. Unless otherwise noted, make all couplings, changes in direction, branch outlets, and transitions to other materials or joining methods with standard manufactured fittings.

B. Do not expand or swage piping in lieu of proper solder fittings.

C. Do not extrude or "pull" branch outlets with "tee-drill" type equipment.

D. Do not use self tapping type branch outlets.

1. See "hot taps" below.

3.5 THREADED JOINTS AND FITTINGS

A. All threaded joints shall be made in accordance with American National Standard B2.1.

1. Do not overthread pipe.
2. Apply pipe joint compound on male threads only.
3. Do not use right and left hand threaded joints to make a "union".

B. Do not thread steel pipe schedule 10 or lighter.

1. UL listed light wall pipe may be threaded in accordance with its listing.

3.6 MECHANICAL COUPLING SYSTEMS

A. All changes in direction shall be made with radius type elbows.

1. Use long radius (R=1.5D) fittings wherever possible.
2. Angles less than 22½º may be made with pre-manufactured metered fittings.
3. Use of the angular deflection capabilities of grooved pipe couplings for intentional changes of direction shall not be allowed.

B. All branch outlets shall be made with pre-manufactured 3-way fittings.

1. Shop fabricated Weld-o-let style welded saddle fittings may be used for branches more than two pipe sizes smaller than the main.
2. Mechanical saddle tap fittings shall not be allowed.

C. Pipe shall be adequately laterally supported to prevent “pipe squirm”. Provide a minimum of one hanger per pipe section. No pipe section shall be left unsupported between any two couplings.

1. Rigid type couplings may be considered equivalent to welded or soldered pipe for the above requirements.

D. Risers more than 20’ high shall be made with rigid type couplings.

E. Grooved pipe systems shall not be considered to be electrically conductive.

1. Provide wire jumpers across all couplings where the piping system is required to be electrically conductive.
2. Cold water piping using grooved pipe systems shall not be used for building ground.
   a. Provide an engraved plastic sign at the building water entrance stating “Mechanical Coupling System”. Not Electrically Conductive”.

F. Flexible couplings may be used for thermal expansion/contraction compensation.

1. Use a minimum of flexible coupling for every foot for chilled water and domestic cold water piping.
2. Use a minimum of 1 flexible coupling for every foot for hydronic hot water or domestic hot water piping.
3. The above is for cut grooved pipe. Double the amount of the connectors with roll grooved pipe and fittings.

3.7 PRESS FIT SYSTEMS

A. Fittings and piping shall be joined in accordance with manufacturer’s installation guidelines.

1. Tubing shall be fully inserted into fitting.
2. Mark all tubes at shoulder of fitting.
3. Press joints using manufacturer approved tool.

3.8 HOT TAPS

A. Installing a branch line in piping while under service or static pressure (hot taps) shall only be done where specifically authorized.

B. Submit the proposed method of procedure for each fluid service and pipe material.

1. Hot tap procedure shall remove a plug of main tap material and retrieve it. The plug shall be a maximum of 1 pipe size smaller than the branch size. Hang the removed plug by a chain at the completed tap.
2. Hot tap procedure shall not affect the temperature or pressure rating of the piping system.
3. Hot tap procedure shall be done through a gate or ball valve.

3.9 SENSOR WELL TAPS

A. Sensor wells shall be placed in taps made in accordance with the above requirements for branch outlets.

3.10 CLEANING, FLUSHING, INSPECTING

A. Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings, if any.

B. Flush out water and piping systems with clean water before proceeding with required tests.

C. See specific pipe service section for further requirements.

3.11 PIPING TESTS

A. Provide temporary equipment for testing, including pump, thermometer and gauges.

B. Test piping system before insulation is installed wherever feasible, and remove control devices before testing.

C. Test each natural section of each piping system independently, but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating.

D. Fill each section of water, drain or vent piping with water and pressurize for two hours at 150% of operating pressure, but not less than 25 psig for pressure piping, and ten feet of head for drain and vent piping.

E. Test fails if leakage is observed, or if temperature compensated pressure drop exceeds 1% of test pressure.

F. Disassemble and re-install sections which fail the test by using new materials to the extent required to overcome leakage.

1. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

G. After testing and repair work have been completed, drain test water from piping systems.

3.12 MECHANICALLY FORMED TEE CONNECTIONS (DOMESTIC WATER SYSTEMS ONLY)

A. Mechanically extracted collars shall be formed in a continuous operation consisting of drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the branch tube wall so as to comply with the American Welding Society lap joint weld. The collaring device shall be fully adjustable as to ensure proper tolerance and complete uniformity of the joint.

B. The branch tube shall be notched to conform with the inner curve of the run tube and have two dimple/depth stops (one ¼" atop the other) to insure penetration of the branch tube into the collar is of sufficient depth for brazing, and that the branch tube does not obstruct the flow in the main line tube. Dimple/depth stops will be in line with the run of the tube. The second dimple shall be ¼" above the first and will serve as a visual point of inspection.

C. All joints shall be brazed in accordance with the Copper Development Association Copper Tube Handbook using BCuP series filler metal. NOTE: Soft soldered joints will not be permitted. Contractor assumes responsibility for joints being installed in accordance with code and manufacturer's recommendation.

D. All mechanically formed branch collars shall be listed by the Standard Plumbing Code, I.A.M.P.O., S.B.C.C. HUD, U.S. Army Corps of Engineers, NAVFAC, and Underwriters Laboratory. They shall also comply with the ASME Code for pressure Piping ANSI B31.5c.

3.13 PLASTIC PIPING

A. Do not test with air pressure.

B. Provide mineral wool fire blanket and tape sealant system to protect all plastic pipe in a return air system.

C. Support all plastic piping in anticipation of 120ºF pipe temperature.

3.14 PAINTING

A. Exposed piping shall be painted. Pipe shall be cleaned by this contractor and ready for priming and painting.

END OF SECTION 230521

SECTION 23 0522 - PIPING ACCESSORIES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Manufacturer's Data - Piping Accessories: Submit manufacturer's data on the following piping accessories:

1. Sealing compound for sleeves.
2. Expansion compensators.
3. Flexible pipe connections.
4. Guides.

B. LEED:

1. Adhesives and Sealants:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standard: South Coast Air Quality Management District (SCAQMD) Rule #1168, July 1, 2005 and Green Seal Standard for Commercial Adhesives GS-36, October 19, 2000.
2. Low-Emitting Paints and Coatings:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standards: Green Seal Standard GS-11, Paints, First Edition, May 20, 1993; Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997; South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, January 1, 2004.

PART 2 - PRODUCTS

2.1 MANUFACTURED PRODUCTS

A. Escutcheon Plates:

1. Type: Split ring
2. Construction: Brass
3. Finish:
   a. At Painted Surfaces: Prime coat
   b. At Other Surfaces: Nickel or Chrome plate
4. For Floor Sleeves: Where sleeves extend above floor surface, provide depth to cover sleeve.

B. Expansion Compensators, Two Inch and Smaller:

1. Manufacturers - Design Basis: Metraflex
2. Other Acceptable Manufacturers:
   a. Adsco
   b. Keflex
3. Model: Metraloop

C. Flexible Pipe Connectors:

1. Manufacturers - Design Basis: Mason
2. Other Acceptable Manufacturers:
   a. Metraflex
3. Model: MFTNC, Twin Sphere 225 psi.

D. Pipe Alignment Guides:

1. Manufacturers - Design Basis: Metraflex
2. Other Acceptable Manufacturers:
   a. Adsco
   b. Keflex
3. Model: Style IV Spider Type guide
4. Material:
   a. Spider: Steel for steel pipe, bronze for copper tubing.
   b. Ring: Steel
   c. Travel: 3”

2.2 FABRICATED ACCESSORIES

A. Steel-Pipe Sleeves: Fabricate from Schedule 40 steel pipe. Remove burrs.

B. Iron-Pipe Sleeves: Fabricate from service weight cast-iron pipe. Remove burrs.

C. Sheet-Metal Pipe Sleeves: Fabricate from galvanized sheet-metal, closed with lock-seam joints.

1. For following pipe sizes, provide gauge indicated:
   a. Three Inch Pipe and Smaller: 20 gauge
   b. Four Inch to Six Inch Pipe: 16 gauge
   c. Over Six Inch Pipe: 14 gauge

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipe Sleeves:

1. Install pipe sleeves where piping passes through walls, floors, ceilings, roofs and structural members, except soil pipe penetrations through concrete slab on grade.
2. Where possible pour sleeve in place or grout.
3. Provide sleeves of adequate size, accurately centered on pipe runs, so that piping and insulation (if any) will have free movement in the sleeve in non-fire rated penetrations.

4. In fire rated penetrations, size sleeves such that the resulting annular space is in accordance with the application requirements of the fire stopping system. Refer to Section 23 05 03. All above grade floor penetrations shall be considered to be fire-rated.
5. Install length of sleeve equal to thickness of construction penetrated, except extend floor sleeves 0.25" above floor finish and, where floor surface drains to a floor drain, extend floor sleeve 0.75" above floor finish.
6. Provide temporary support of sleeves during placement of concrete and other work around sleeves.
7. Provide temporary closure to prevent concrete and other materials from entering pipe sleeves.
8. Except as otherwise indicated, install steel pipe sleeves.
9. At interior partitions and ceiling, install sheet metal sleeves.
10. At exterior penetrations below grade, install iron pipe sleeves.
11. Seal exterior sleeve penetrations at grade weather tight.

B. Caulking:

1. Where water seal or sound seal, but not fire seal, is needed, (foundation walls, slab on grade): fiberglass backing and heavy bead of silicone caulking compound.
2. Where sleeve pierces a fire separation: Fire stop material in accordance with manufacturer's directions and UL listing. Refer to Section 23 05 03.

C. Install escutcheon plates at pipe sleeves where piping is exposed to view in occupied spaces of the building, on the exterior, and elsewhere as indicated.

D. Compensators: Install where shown or where required because piping arrangement does not provide sufficient flexibility.

1. Protect compensators from over-travel and over-stress during remaining installation and testing.

E. Flexible Connectors: Install at right angles to displacement.

1. Install one end immediately adjacent to isolated equipment and anchor other end.

F. Guides: Install where shown and where required in accordance with expansion compensators published requirements.

1. As a minimum, install one guide within four pipe diameters of compensator, and one guide 14 pipe diameters from first guide.

END OF SECTION 230522

SECTION 23 0523 - VALVES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's product data including:

1. Dimensions
2. Sizes
3. End Connections
4. Weights
5. Installation instructions
6. Instructions on repacking and repairing valves.
7. Range of flow for balancing valves and plug valves.

B. Valve Tag List: Refer to Section 23 05 53 of the Specifications.

PART 2 - PRODUCTS

2.1 VALVES TYPES AND SIZES

A. General:

1. Where type or body material is not indicated, provide valve with pressure class selected from MSS or ANSI standards, based on the maximum pressure and temperature in the piping system.
2. All valves in contact with domestic water shall meet the requirements of NSF/ANSI Standard 61.
3. Except for balancing or otherwise indicated, provide valve of same size as connecting pipe size.
4. Unless specifically required by note or symbol, all water valves shall be ball or butterfly valves. If ball, butterfly, globe, plug, or balancing valves are called out by note or symbol, only that type of valve is acceptable.
5. Ball valves or butterfly valves may be used in lieu of gate valves when pressure and temperature ratings are adequate.
6. Where pipe sizes overlap, contractor has the option of threaded or flanged valves.
7. Where grooved pipe mechanical coupling systems are accepted, provide flange adapters to mate with valves as specified below. Valves by the mechanical coupling system manufacturer shall not be used unless they meet all of the specified requirements for a given valve.
8. All valves shall be domestically manufactured unless approved for use by Engineer.
9. Valves used for domestic water service shall be bronze or stainless steel. Iron and brass body valves are not acceptable.
10. All components in hydronic systems shall be compatible with propylene glycol and water solution.

2.2 GLOBE AND ANGLE VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Powell
   d. Victaulic (for Grooved Pipe Systems)
   e. Gruvlok
   f. Stockham

B. Size 2” and Smaller: Bronze, 125 psi SWP, 200 psi WOG, rising stem, screwed bonnet. Bronze disk, MSS SP-80, Type 1.

1. Model:
   a. Globe, Solder Ends: 1502
   b. Globe, Threaded Ends: 502
   c. Angle: 504

C. Size 2½” and Larger: 125 psi SWP, 200 psi WOG, OS&Y bolted bonnet, gland packed, bronze disk, removable bronze seat ring, MSS SP-85.

1. Model:
   a. Globe: F-2981

2.3 SWING CHECK VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers;
   a. Crane
   b. Nibco
   c. Powell
   d. Stockham
   e. Victaulic (for Grooved Pipe Systems)
   f. Gruvlock

B. Size 2” and Smaller: Bronze, 200 psi SWP, 400 psi WOG, straight or Y-pattern, Bronze Disk, MSS-SP80 Type 3.

1. Model: 508

2.4 SILENT/WAFER CHECK VALVES

A. Manufacturers:

1. Design Basis: Metra Flex

2. Other Acceptable Manufacturers:
   a. Cla-Val
   b. GA Industries
   c. Nibco
   d. Tyco
   e. Victaulic (for Grooved Pipe Systems)
   f. Gruvlok
   g. Stockham

B. Size 2” and Smaller: Bronze body, 200 psi @ 250 °F, threaded ends, resilient seats, center guided disk.

1. Model: 5700

C. Pipe size 2 1/2 “ and Larger: Iron body, bronze or stainless steel trim, class 125, 316 stainless steel spring, dual plate or tilting disk type, resilient seat, minimum C_V: 4”-280, 8”-1200, 12”-4000.

1. Model: 810

2.5 BUTTERFLY VALVES

A. Manufacturers:

1. Design Basis: Keystone
2. Other Acceptable Manufacturers:
   a. Crane
   b. Center Line
   c. Nibco
   d. Keystone
   e. Victaulic (for Grooved Pipe Systems)
   f. Hammond Watts
   g. Bray
   h. Gruvlok
   i. Stockham

B. Water Service (less than 250ºF): 200 psi WOG, cast or ductile iron fully lugged body, integral extended neck to clear insulation, integral top plate for actuator mounting, stainless steel stem, upper and lower lubricated bushings, field replaceable hard back seat with integral stem and flange seals, machined disk seating areas, rated for minimum 150 psi dead end service with no downstream flange. Liner to be compatible with operating fluid. Conform to MSS-SP67.

1. Disk Material - 8” and Under and all sizes for condenser or domestic water: Aluminum bronze.
2. Disk Material, 10” and Larger: Nickel plated ductile iron.
3. Model: Figure 2-22.

C. Accessories:

1. 10 position locking lever handler for valves 6” and smaller.

2. Infinite position memory stop lever handle for all valves 6” and smaller used for balancing.
3. Hand wheel gear operator for valves 8” and larger.
4. Chain wheel operator where required.

2.6 GATE VALVES

A. Manufacturers:

1. Design Basis: Milwaukee
2. Other Acceptable Manufacturers:
   a. Crane
   b. Nibco
   c. Stockham
   d. Victaulic (for Grooved Pipe Systems)
   e. Gruvlok

B. Size 2” and Smaller: Bronze 125 psi SWP, 200 psi WOG, rising stem, threaded bonnet, gland packed MSS SP-80 Type 2.

1. Model: 148

C. Size 2½” and Larger: Cast iron, 125 psi SWP, 200 psi WOG, gland packed, bolted bonnet, OS&Y, solid wedge disk, either all bronze or with bronze face ring, bronze seat rings, brass back seat bushing, brass stem, bronze yoke bushing.

1. Model: F2885

2.7 BALL VALVES

A. Manufacturers:

1. Design Basis: Nibco
2. Other Acceptable Manufacturers:
   a. Apollo
   b. Dyna Quip
   c. Hammond
   d. Milwaukee
   e. Victaulic (for Grooved Pipe Systems)
   f. Watts
   g. Bray
   h. Gruvlok
   i. Stockham

B. Bronze, 150, SWP, 600 WOG (min), chrome plated solid, tunneled bronze ball (stainless for steam service), two piece design, blow-out proof stem, adjustable packing gland nut (allowing handle to be removed without leaking) TFE seats, MSS-SP-110.

1. Model: T-585-70 - full.port.

C. Options: Provide the following where required:

1. Extended stems for insulated valves.
2. Memory stop device for balancing applications.
3. Tee handle for tighter areas.
4. Hose end and cap for drain.
5. Mounting pads for actuator.
6. “Stop and drain” for compressed air.

2.8 BALANCING VALVES

A. Manufacturers:

1. Design Basis: Tour and Anderson (Victaulic).
2. Other Acceptable Manufacturers:
   a. Armstrong
   b. Nibco
   c. Hays

B. Contractor to select either manual or automatic balancing valves for given sizes. All balancing valves of same size shall be same type.

C. Manual Balancing Valves (1/2" through 2"):

1. 300 psi/2065 kPa, y-pattern, globe type with soldered or threaded ends, non-ferrous DZR brass copper alloy body, EPDM O-ring seals. 4-turn digital readout hand-wheel for balancing, hidden memory feature with locking tamper-proof setting, and connections for portable differential meter.
2. The balancing valves shall be Y-pattern globe style design and all metal parts of nonferrous, pressure die cast, nonporous DZR Brass. Each valve shall provide four (4) functions:
   a. Precise flow measurement
   b. Precision flow balancing
   c. Positive shut-off with no drip seat, eliminating the need of an additional isolation valve.
   d. Drain connection using 3/4" NPT hose end thread.
3. These valves shall have four 360' adjustment turns of the hand-wheel for precise setting with hidden memory to provide a tamper-proof balancing setting. Hand-wheel shall have digital readout. The hand-wheel can be installed in any position without affecting performance.

D. Automatic Balancing Valves (1/2" through 1-1/2"):

1. Balancing accuracy shall be within 10% of maximum flow.
2. Suitable for up to 600 psig. 32°F to 225°F operating temperature range.
3. Select cartridges based on maximum flows listed in equipment schedules. Valves shall provide automatic control over a 40 to 1 differential pressure operating range (2-80 psi). Differential pressure control cartridges shall be changeable after installation in case of flow rate change.
4. All valves shall have permanent label indicating model number, size, and flow.

5. Provide with pressure/temperature taps for verification of pressure drop.
6. Materials:
    a. Diaphragm: Elastomeric.
    b. Orifice: Brass or polyphenylsulfone.
7. The balancing valves shall be Y-pattern globe style design and all metal parts of nonferrous, pressure die cast, nonporous DZR Brass. Each valve shall provide four (4) functions:
    a. Precise flow measurement
    b. Precision flow balancing
    c. If used as equipment isolation, provide positive shut-off with no drip seat.
    d. If provided with strainer, provide drain connection using 3/4" NPT hose end thread. Otherwise drain connection shall be provided on strainer.

E. Balancing Valves (2-1/2” - 16"):

1. 300 psi/2065 kPa, y-pattern, globe type with flanged or grooved ends, ASTM A536 ductile iron body, all other metal parts of DZR brass copper alloy, EPDM O-ring seals. 8, 12, 16, 20, or 22 turn digital readout hand-wheel for balancing, hidden memory feature with locking tamper-proof setting, and connections for portable differential meter.
2. Flanged and grooved with digital hand-wheel. The balancing valves shall be Y-pattern globe style design with ductile iron body all other wetted parts of nonferrous, pressure die cast DZR Brass. Each valve shall provide three functions:
    a. Precision flow measurement
    b. Precision flow balancing
    c. Shut-off feature, eliminating the need of an additional isolation valve
3. These valves shall have a minimum of (8) 360 degree adjustment turns of the hand-wheel for precise setting with hidden memory feature to program the valve with precision tamper-proof balancing setting. Hand-wheel shall have digital readout. The hand-wheel can be installed in any position without affecting performance.

2.9 CIRCUIT SETTERS (CS) – DOMESTIC WATER APPLICATIONS ONLY

A. Manufacturers:

1. Design Basis
    a. Bell & Gossett/ITT
2. Acceptable Manufactures:
    a. Victaulic
    b. Prior Engineer Approval for Substitutions

B. Construction:

1. All valves to be of brass body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT insert and check valve. Valve bodies to have ¼” NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplate to assure specific valve setting. Valves to be leak-tight at full rated working pressure.

C. Valves ½" to 2" pipe size, NPT or sweat valves 2 ½' and 3" pipe size, NPT.

D. Pressure/Temperature 175 psig at 250°F.

E. ANSI/NSF-61 certified.

2.10 COMBINATION THROTTLING/CHECK VALVES

A. Manufacturers:

1. Basis of Design: Bell & Gossett Triple Duty Valve.
2. Other Acceptable Manufacturers:
   a. Armstrong
   b. Taco
   c. Victaulic (for Grooved Pipe Systems)
   d. Watts

B. Features:

1. 175 psi, 250ºF water working pressure.
2. Globe style valve with stainless steel spring loaded brass disk guided and limited by a brass or stainless steel stem.
3. Resilient seat.
4. Able to be re-packed under pressure.

2.11 DRAIN VALVES

A. Gate or ball valve with hose end adapter and cap.

2.12 PLUG VALVES

A. Manufacturers:

1. Design Basis: Keystone
2. Other Acceptable Manufacturers:
   a. Dezurik

B. Model: "Ballcentric"; cast-iron, full port body; EPDM coated plug; welded nickel seat; stainless steel bearings; integral memory stop device; hand wheel operator for valves 6" and larger.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the following requirements:

1. Install valves except butterfly with stems pointing up, and as close to vertical as possible. Butterfly valves to be offset at least 10° from vertical.

2. Install valves at each piece of equipment, fixture or appliance so that the supply and return services can be shut off to remove the item without draining the remainder of the piping system.
3. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping.
   a. Locate valves so as to be accessible.
4. Combination balancing and shut-off valves may be used instead of a separate balancing valve and shut-off valve if the valve has a memory stop and the manufacturer lists its use as a leak-proof service valve.
5. Provide drain valves at main shut-off valves, low points of piping and apparatus.
6. Provide separate support where necessary.
7. Do not allow meter connections of balancing valves to point downward.
8. Install valves so bypass valves are accessible.

B. All valves of a given type shall be of one manufacturer.

C. Provide extended stems on insulated system to prevent interference of operator with insulation.

D. Provide chain wheel operators for valves more than 8’ – 0” AFF in mechanical rooms and wherever shown on drawings.

3.2 CHECK VALVE INSTALLATION

A. Swing and Check Valves:

1. Install only in horizontal lines unless absolutely impractical. If installed vertically, flow shall be upwards.
2. Do not install in pump discharge piping.

B. Silent Check Valves:

1. Install in all pump discharge lines.
2. Silent check valves may be installed in vertical pipes with flow down upon Engineer’s review for each instance.

3.3 VALVES USED FOR THROTTLING/BALANCING

A. Balancing valves shall not be used for flow indication in pipes 2½” and larger, or in pump discharge piping.

B. Flow indication in piping 2½” and larger and in pump discharge piping, shall be by a venturi with a plug, butterfly, or globe valve for throttling.

C. Throttling/Balancing Valves shall be selected so that the maximum design flow causes between 1’ and 10’ W.G. pressure drop or meter reading with the valve wide open.

D. Install balancing valves used for flow indication with a minimum of five times the pipe diameter downstream and two times the pipe diameter upstream of a fitting or valve.

E. Globe, ball, butterfly, or plug valves may be used for throttling/balancing. Provide an infinitely variable, lockable memory stop device to allow the valve to be returned to the "balanced" position after closing, and to prevent movement of the disk or plug during operation. When ball valves are used for throttling, provide an additional valve for equipment isolation.

F. Balancing valve sized to flow.

G. Insulation: Provide pre-molded insulation conforming to the valve body. Material shall have a flame spread of 25 and a smoke development of 50.

3.4 COMBINATION THROTTLING/CHECK VALVES

A. Combination throttling/check valves may be used in lieu of separate throttling and check valves on pump discharge piping. However, they may not be used for flow measurement.

3.5 CIRCUIT SETTERS

A. All circuit setters shall be installed per manufactures recommendations. Provide manufacturers recommendation for required straight pipe for inlet and outlet connections to provide accurate ratings. Setting shall be 1 GPM unless otherwise noted on drawings.

END OF SECTION 230523

SECTION 23 0529 - PIPE SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 STANDARDS

A. Comply with MSS Standard Practice SP-69, published by Manufacturer's Standardization Society of the Valve and Fitting Industry for type and size.

1.2 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Hangers other than clevis type.
2. Anchors.

B. Submit structural calculations on trapeze type supports.

C. Submit product data and calculations to project structural engineer for review. Submittals shall include compliance documentation with current Codes.

PART 2 - PRODUCTS

2.1 PIPE HANGERS

A. General:

1. Use adjustable pipe hangers on suspended pipe. Trapeze hangers may be used at the Contractor's option. Contractor shall be responsible for sizing supports.
2. Chain, wire or perforated strap hangers will not be permitted.
3. Isolate hangers in contact with dissimilar materials with dielectric hanger liners. Tape is not acceptable.
4. Provide supports between piping and building structure where necessary to prevent swaying.

B. Hanger and Rod Material:

1. Exposed in public areas: Zinc electroplated steel.
2. Concealed or in service areas: Black threaded steel.
3. Outside, exposed to weather: Hot dipped galvanized.
4. Buried below structural slab: Stainless Steel

C. Cast-In- Place Inserts:

1. Cast-in-place inserts system shall be used.
2. Inserts to be UL and FM listed for their application.

3. Anchors shall comply with Allowable Stress Service loads l per the Code.
4. Inserts shall conform to ASTM A307.
5. Size inserts to match size of threaded hanger rods.

D. Channel Type Inserts:

1. Standard channel support with anchor tabs on 4" centers, and nail holes for attaching to forms.
2. Styrofoam inserts to prevent wet concrete seepage.
3. Minimum 2000 pounds/foot capacity.

E. Expansion Anchors:

1. For use only where modifications to piping layouts to change from pre-installed insert locations and only under approval from the Engineer.
2. Inserts shall be wedge-type with current ICC approval and published ICC Research Report.
3. Anchors in concrete shall be ICC approved and shall be installed in strict accordance with approved ICC "Research Reports" for the specific anchor used.
4. Manufacturers:
   a. Hilti- Kwik-Bolt TZ
   b. Simpson Strong Bolt
   c. Phillips ITW Trubolt
5. Power driven fasteners are not acceptable.
6. "Drop-in" type anchors are not acceptable.
7. Anchors shall be complete with all required nuts, washers.
8. Installed per Manufacturer's recommendations.
9. Interior: Carbon steel anchors complying with ASTM A307.
10. Exterior or Wet Environment: Series 300 stainless steel anchors, nuts and washers.
11. Anchors shall comply with loading requirements per the Code.

F. Steel Structure Attachments:

1. Contractor may select welded or mechanically attached. All mechanically attached supports shall have jam nuts or other means to prevent loosening. Maximum loading requirements are as follows:

Rod Size	**Maximum Working Load**
3/8	600 pounds
½	1100 pounds
5/8	1800 pounds
¾	2700 pounds
7/8	3700 pounds

G. Single Hangers:

1. Piping 2" and smaller: MSS type 1, Clevis hanger or type 7 adjustable swivel ring hanger. Minimum 180 pounds design load.
2. Piping 2½" and larger: MSS type 1 Clevis hanger.

3. Bare copper pipe: Above hangers, plastic or Neoprene coating, sized for copper pipe O.D. and copper coated for identification.
4. Insulated pipe: Hangers to be sized for O.D. of insulation. Hangers shall not penetrate any insulation.

H. Trapeze hangers and wall supports:

1. Channel strut or structural steel shapes. Contractor shall follow channel strut manufacturers guidelines for loading or provide structural steel supports designed by a professional Engineer, licensed in the same state as where the project is located.
2. All piping shall be attached to the support by means of a channel strut clamp, U-bolt, or pipe rollers which will maintain lateral position of the pipe but allow longitudinal movement. Provide dielectric isolation between all dissimilar metals.
3. All insulation shall be continuous at supports. Do not notch or penetrate insulation.

I. Vertical Supports: Steel riser clamp at each floor penetration or every 14 foot supported from wall bracket. Do not anchor riser clamps.

J. Hangers:

1. General: Adjustable wrought steel clevis with locking nut attachment.
2. Multiple or Trapeze: Steel channels with welded spacers and hanger rods.
3. Hanger Sizes and Spacing:
   a. For gas, domestic water and drain piping, conform to the District of Columbia Plumbing Code for spacing, and the following table for hanger rod sizes.
   b. For steam and hydronic piping, conform to the following table:

PIPE TYPE	PIPE SIZE	MAXIMUM SPACING	MINIMUM HANGER ROD SIZE
Steel Pipe	½”	6’-0”	3/8”
	¾” thru 1¼”	8’-0”	3/8”
	1½” and 2”	10’-0”	3/8”
	2½” thru 3½”	12’-0”	½”
	4” and 5”	15’-0”	5/8”
	6”	17’-0”	¾”
*	8” thru 12”	12’-0”	7/8”
*	14” thru 18”	10’-0”	1¼”
*	20” thru 30”	8’-0”	1½”
Copper Pipe	½” thru 1”	6’-0”	3/8”
	1¼” thru 2”	10’-0”	3/8”
	2½” thru 3”	10’-0”	½”
Cast Iron Soil	2”		3/8”
	3” to 5”		½”
	6”		5/8”
*	8” to 12”		¾”

* Submit routing and support plans to Architect/Engineer for review.

K. Insulated Pipe Supports:

1. Size pipe supports for outside diameter of pipe insulation.

L. Wall Supports:

1. ½" through 3": Unistrut type channel and steel clamp.
   a. Use Hydrosorb cushions on copper pipe.
2. 4" and Over: Welded steel bracket and wrought steel clamp.

M. Pipes over five inches and over 120º: Provide cast iron roller supports.

2.2 INSULATION INSERTS

A. All insulated pipes shall be protected at the point of support by insulation inserts. Insert to be same thickness as adjoining pipe insulation. Materials shall be suitable for use in an air plenum.

B. Provide any of the following products:
1. High density, 100 psi, waterproofed calcium silicate, encased in a sheet metal shield. Shield shall extend one inch beyond sheet metal shield. If pipe hanger spacing exceeds ten feet and for all pipe roller applications, utilize double layer shield on bearing surface.
2. Trymer Polyisocyanurate Foam insulation (urethane). Provide compressive strength and temperature range as required for pipe served. Insert shall be provided with factory applied vapor barrier.
   a. Manufacturers: Snapp Itz Mechanical Pipe Shields (BBMI, LLC) or pre-approved equal.
   b. Not for use on steam piping or other piping above 225° F.

C. Provide 180º insulation inserts when utilizing clevis hangers. Provide 360º insulation inserts at all trapeze and wall supports.

2.3 PIPE ANCHORS

A. Manufacturers:

1. Design Basis: Flexonics
2. Other Acceptable Manufacturers:
   a. Adsco
   b. Keflex
   c. Hilti

B. Model AC with threaded ends and welded angle brackets for steel pipe.

C. Model AC copper tube with solder ends and steel angle brackets brazed to tubing for copper tube.

D. Anchors may be field fabricated similar to manufactured products specified.

2.4 PIPE GUIDES

A. Manufacturers:

1. Basis of Design: B-line.
2. Other Acceptable Manufacturers:
   a. Fee & Mason
   b. Grinnel
   c. M-Co
   d. PHD

B. Any of the Following:

1. Spider Type: B3281-7.
2. Roller Type: 2 sets of roller son opposite sides of pipe.
3. Slide Type: B3893 with hold down lugs.
   a. Not for use with cold piping.
4. Light duty, 1½" and smaller copper: U bolt or channel strut clamp (B2417) allowing clearance from O.D. of pipe or insulation.

2.5 ROOF MOUNTED PIPING

A. Manufacturers:

1. Miro Industries, Inc.
2. Portable Pipe Hangers, Inc.
3. Approved Equivalent.

B. Description: Piping on roof shall be supported by an engineered prefabricated portable pipe system specifically designed to be installed on the roof without roof penetrations, flashing or damage to the roofing material. The system shall consist of recycled rubber or plastic bases, hot dipped galvanized or stainless steel frame with threaded rods and suitable pipe hangers and supports. The system shall be custom designed to fit the piping and conduits to be installed and the actual conditions of service.

C. Provide seismic restraints as required for seismic zone. See 23 05 49.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE SUPPORTS

A. Adequately support piping from the building structure with adjustable hangers to maintain uniform grading where required and to prevent sagging and pocketing.

1. Provide supports between piping and building structure where necessary to prevent swaying.
2. Do not support pipe from other pipe or equipment.
3. Provide thrust restraints at all changes in direction on 8" and larger cast iron piping with no hub or hub and spigot fittings.

B. Install hangers to provide minimum ½" clear space between finished covering and adjacent work.

1. Place a hanger within one foot of each horizontal elbow.
2. Space hangers generally as called for in Table in Part 2, Products.

C. Use hangers, which are vertically adjustable 1-½" minimum after piping is erected.

D. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

1. Set inserts in position in advance of concrete work.
2. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
3. Do not penetrate concrete "TT" legs for piping inserts. Do not penetrate the stressed (i.e. lower) chords of any structural member.

E. Expansion anchors: For use only where modifications to piping layouts to change from pre-installed insert locations and only under approval from the Engineer.

1. Installation shall be strict compliance with ICC Research Report criteria.
2. Expansion anchors require special inspection as required by their ICC Research Report.
3. Special inspector shall make periodic inspections of installation for compliance with manufacturer's installation instructions.

F. Provisions for Movement: Install hangers and supports:

1. To allow controlled movement of piping systems.
2. To permit proper movement between pipe anchors.
3. To facilitate the action of expansion joints, expansion loops, bends and offsets.
4. To isolate force due to weight or expansion from equipment connections.

G. In general, attach hangers to upper chord of roof trusses and floor joists, using long rods to facilitate pipe movement.

H. Anchors:

1. Use no pipe anchors. Arrange piping such that pipe expansion and contraction is accommodated by controlled movement of the pipe within the pipe supports. Provide sufficient offsets in branch piping to accommodate movement of main piping due to expansion and contraction.

END OF SECTION 230529

SECTION 23 0530 - ELECTRONIC SPEED CONTROLLERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data for each unit. Include:

1. Capacity:
   a. Horsepower
   b. KVA
   c. Amps
2. Wiring Diagrams:
   a. Include diagrams for basic unit and for all required accessories.
3. Dimensions.
4. Installation instructions.
5. Description of diagnostic system.
6. Options provided.
7. Time-current curves for VFD circuit.

B. Show compliance with IEEE 519 – provide harmonic analysis for project jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD). The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFDs shall include a minimum of 5% impedance reactors, no exceptions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer:

1. Basis of Design:
   a. Toshiba
2. Other Acceptable Manufacturers:
   a. Reliance
   b. Robicon
   c. Hitachi
   d. Magnetek
   e. Cutler-Hammer
   f. ABB
   g. Danfoss
   h. General Electric
   i. Trane
   j. Yaskawa

B. Single Manufacturer

1. Provide all drives, except those factory mounted, by a single manufacturer.
2. "Factory Mounted" means as part of a packaged unit where the drive is not purchased separately from the driven equipment.

C. Drive shall convert the constant frequency AC line voltage to a variable frequency, variable voltage AC output suitable for control of a standard NEMA design B induction motor over a 10:1 speed range and with full load amp rating between 10% and 110% of the drive full load current capability and without modification to the motor or the drive.

D. Variable frequency drives for motors greater than 5 HP shall have the following features:

1. Drive input: 480 volts $\pm$ 10%, 3 phase, 60 Hz.
2. Drive output: 0-460 volts, 3 phase, 0-80 Hz. For efficient operation of a variable torque load.
3. Drive type: Pulse width modulation type, designed to minimize harmonic generated noise in the motor.
4. Enclosure type: NEMA 1 or NEMA 4 depending upon mounting location. Unit to operate in ambient temperatures of -40F to 155F
5. AC line fused disconnect or circuit breaker.
6. Metal oxide varistors on incoming line for transient protection.
7. Control power transformer with fused primary and 24V or 120V fused secondary.
8. Manual, speed adjustment potentiometer of keypad, HAND-OFF-AUTO switch, and 4-20 milliamp signal follower, fully isolated and suitable for grounded or ungrounded input signal. Drive manufacturer shall coordinate exact signal type with temperature control contractor.
9. Instantaneous overcurrent shutdown with indicator light when current exceeds 200%. Time-overcurrent overload protection for the motor.
10. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
11. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
12. Input phase loss and undervoltage protection.
13. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
14. Drives shall be capable of "riding through" a momentary loss of power for up to 2 seconds.
15. AC line reactors in the drive cabinet for protection against line notching and surges without requirement for an input isolation transformer.
16. Power factor shall be minimum 95% at all speeds and loads.
17. Each drive shall have the following status and troubleshooting diagnostic features:
    a. Auto restart in "auto" mode. Certain drive faults shall be selectable to bypass the auto restart feature. Auto restart manual shall only be attempted 5 times.
    b. Exterior drive door mounted devices shall include"
        1) "Power On" pilot light.
        2) "VFD Run" pilot light.
        3) % full load digital display.
        4) Output frequency and/or % speed digital meter.

c. Indicator lights on each power module to indicate correct operation (or failure) of individual owner switching devices.
d. DRIVE/OFF/LINE test switch.

18. UL listed or ETL listed.
19. Minimum and maximum speed adjustment.
20. Factory Tests: The VFD shall be tested with the system logic and given complete factory tests including simulated operation.
    a. Provide certification this test has been made for the particular units shipped for this job.
21. Field Adjustments: Independent acceleration/deceleration rates: 0.5 – 120 seconds.
22. Provide a maximum of 1000 volts at the motor terminals.
23. Provide LAN card connection to interface with Building Automation System. Coordinate control protocols with BMS contractor.
24. Provide auxiliary contacts for connection to smoke control system. VFD to be UL864 listed for smoke management.

E. All variable frequency drives shall be equipped with a manual bypass device to allow for total isolation of the drive unit for service while providing for temporary operation of the motor. This shall include:

1. A main disconnect switch in the bypass enclosure with a door interlock handle. This disconnect shall provide positive shutdown of all power to both the bypass circuitry and the VFD.
    a. For motors on emergency, or life safety systems, the bypass shall be in a separate compartment from the VFD. The installation shall allow for removal of the VFD while maintaining operation of the load.
2. With the “H-O-A” switch in the “OFF” position, the run circuit will be open and the VFD will not operate.
3. A VFD output contactor and a constant speed contactor.
4. A three pole motor overload relay with heaters connected to shut down the motor in both the VFD and bypass modes.
5. A control relay and terminal blocks which will allow two-wire, start-stop control of the motor from a single remote contact in both VFD and BYPASS (AUTO) modes of operation.
6. A control relay and terminal blocks to allow connection of remote interlock shutdown contacts such as freezestats, smoke detectors, etc. When this interlock loop is opened, operation of the motor shall be disabled in both VFD and bypass modes.
7. A three position selector switch shall be provided, VFD-OFF-BYPASS.
8. Indicator lights on the face of the bypass panel shall be provided as follows: Indicators shall be long life neon or transformer type incandescent types.
    a. “POWER ON”
    b. “MOTOR ON VFD”
    c. “MOTOR ON BYPASS CONTROL”
    d. “MOTOR OVERLOAD”
    e. “INTERLOCK SHUTDOWN”
9. 120V control power transformer with fused secondary and primary. Bypass mode operation shall be independent of VFD control power.
10. VFD output contactor shall be wired to allow a controlled VFD deceleration ramp to stop.

11. Panel shall be arranged to allow power-off maintenance of VFD while motor is operation on bypass. Bypass circuitry in the same compartment as the VFD will not be allowed.

F. In addition to the above feature all drives shall have the following additional features:

1. Catch-a-spinning load capability.
2. Critical speed avoidance capability.
3. Where the building walls are not suitable for mounting drives a floor stand kit shall be provided.
4. Where required by Division 23 09 01, provide output isolator to provide VFD signal operation of frequency, and current to an isolated 4-20 mA signal for transmission to the building automation system for monitoring capability.

G. For variable frequency drives serving multiple motors, the following shall be provided:

1. Provide motor contactors for each motor for drives serving more than one motor, each contactor shall have auxiliary contacts to prevent drive damage if remote motor disconnect switch is open of closed.
2. Each drive shall have contactors for each motor it serves with individual thermal overload protection for each motor and H-O-A motor select switch.
3. All multiple motor variable speed controllers shall be capable of operating even if one of the motors is off.

H. For drive manufacturers who use portable test meter for diagnostics, provide not less than one test meter for each model or type used. Meters shall be supplied to the Owner upon completion of the project.

I. Provide one complete set of spare fuses for all variable speed controllers.

J. Interlock all disconnects with variable speed drive so variable speed drive opens before disconnect opens to prevent damage to the drive.

PART 3 - EXECUTION

3.1 Deliver units to installer of electrical work. Provide installation and wiring instruction and diagrams.

3.2 Provide wiring control diagrams and instructions to installer of automatic temperature controls.

3.3 Provide factory representative at start-up to check installation and instruct Owner.

END OF SECTION 230530

SECTION 23 0548 - VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract, and Division 1 Specification Sections (General Requirements), apply to this Section.

1.2 DESCRIPTION

A. Furnish and install vibration control devices, materials, and related items. Perform all work as shown on the drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.3 MATERIAL AND EQUIPMENT

A. Design Basis: Mason Industries

B. Alternate Manufacturers:

1. Amber/Booth Co.
2. Korfund Dynamics Corp.
3. Vibration Eliminator Co.
4. Vibration Mountings & Controls, Inc.
5. Kinetics
6. Vibro-Acoustics

C. Unless otherwise specified, supply only new equipment, parts and materials.

1.4 QUALITY ASSURANCE

A. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Supply and install any incidental materials needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim or additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer’s specifications.

E. Should any rotating equipment cause excessive noise or vibration, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and

vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

1.5 SUBMITTALS

A. Reference Division 1.

B. Prior to ordering any products, submit shop drawings or the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal.

1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
2. Detailed selection data for each vibration isolator supporting equipment, including:
    a. The equipment identification mark;
    b. A cut sheet of the isolated equipment showing equipment support points and operating weight at each point.
    c. The isolator type;
    d. The actual load;
    e. The static deflection expected under the actual load;
    f. Specified minimum static deflection;
    g. The additional deflection-to-solid under load;
    h. The ratio of spring height under load to spring diameter.
3. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
4. Special details necessary to convey complete understanding of the work to be performed.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION MOUNT TYPES

A. General:

1. All metal parts of vibration isolation units installed out-of-doors shall be cold-dip galvanized, cadmium plated, or neoprene coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.
2. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.
3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, laborsaving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories must not degrade the vibration isolation system.
4. Static deflection of isolators shall be as provided in SECTION 3 - EXECUTION. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable

and will be disapproved.

B. Type FSN (Floor Spring and Neoprene)

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts.
2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer's recommended range.
3. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The NP isolator, separator plate and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
4. If the isolator is to be fastened to the building structure and Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.

   Type FSN isolators shall be Mason Type SLF with the appropriate neoprene pad (if used) selected from Type NP or approved equal.

C. Type FSNTL (Floor Spring and Neoprene Travel Limited)

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall not be less than 0.8 of the compressed height of the spring at the rate load. Spring shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts. All mounts shall have vertical travel limit stops to control extension when weight is removed. The travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of ¼" shall be maintained around restraining bolts and between the limit stops and the spring to avoid interference with the spring action.
2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer's recommended range. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The NP isolator, separator plate, and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
3. If the isolator is to be fastened to the building structure and Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. Hold down

assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.

Type FSNTL isolators shall be Mason Type SLR with the appropriate neoprene pad (if used) selected from Type NP or approved equal.

D. Type FN (Floor Neoprene)

1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

   Type FN isolators shall be Mason Type ND or approved equal.

E. Type FNC (Floor Neoprene Chiller)

1. Neoprene isolators shall be double neoprene-in-shear type with steel reinforced top intermediate plates and base. Neoprene elements shall be ¾". Steel plates shall be ¼" and the top and bottom plates shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

   Type FNC isolators shall be Mason Type ND: Fabricate of type "Super W" pads, similar to Type ND otherwise.

F. Type NP (Neoprene Pad)

1. Neoprene pad isolators shall be one layer of ¼" to 3/8" thick ribbed or waffled neoprene. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

   Type NP isolators shall be Mason Type W or approved equal.

G. Type DNP (Double Neoprene Pad)

1. Neoprene pad isolators shall be formed by two layers of ¼" to 3/8" thick ribbed or waffled neoprene, separated by a galvanized steel, stainless steel or aluminum plate. If the isolator is outdoors, the plate shall not be made of galvanized steel. These layers shall be permanently adhered together. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

   Type DNP isolators shall be Mason Type WSW or approved equal.

H. Type HSN (Hanger Spring and Neoprene)

1. Vibration isolation hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing

through a 30º arc before contacting the housing. Hangers shall provide a means to adjust hanger elevation under load. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. The neoprene element shall be designed to have a 0.3" minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.

Type HSN isolators shall be Mason Type P30N or approved equal.

I. Type HN (Hanger Neoprene)

1. Vibration isolation hangers shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30º arc before contacting the hanger housing.

Type HN isolators shall be Mason Type HD or approved equal.

2.2 EQUIPMENT BASES

A. Type BIB (Base - Inertia Base)

1. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lbs./cu.ft.) and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base which will not twist, racks deform, deflect, or crack in any manner which would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 1/12 the longest dimension of the inertia base, but not less than 6" nor more than 12". The base foot print shall be large enough to provide stability for supported equipment. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
2. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Concrete may be provided by the General Contractors.

Frame and reinforcement for Type BIB bases shall be Mason Type KSL or approved equal.

B. Type BC-1 (Base - Curb)

1. Curb type isolation bases shall be a prefabricated assembly consisting of an extruded aluminum frame and steel spring isolation system that fits over the roof curb and under the isolated equipment. The aluminum frame shall be sufficiently rigid to support the equipment load without detrimental twist or deflection. Spring isolators shall be selected

and positioned along the curb to achieve the minimum static deflection called for in the schedule. The static deflection shall be constant around the entire periphery of the base. Springs shall be free standing, laterally stable with a diameter of not less than 0.8 times the compressed height, and have additional travel-to-solid that is at least 50% of the rated deflection. Resilient neoprene snubbers shall be provided at the corners of the base to limit the movement of the equipment under wind load to ¼".

2. The isolation curb base shall be made weather tight by sealing all around the periphery with closed cell neoprene or flexible vinyl. This shall in no way inhibit the vibration isolation of the spring elements. A closed cell sponge gasket or field caulking shall be used between the equipment unit and the isolation curb base and between the isolation curb and roof curb to form a weather-tight seal.
3. Each spring isolator used in the curbs shall be weather protected as described above.

Type BC-1 vibration isolation curb bases shall be Mason Type CMAB or approved equal.

2.3 RESILIENT LATERAL GUIDES

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN which are specifically designed to provide resilient lateral bracing of duct or pipe risers.

Resilient lateral guides shall be Mason Type ADA.

2.4 FLEXIBLE DUCT CONNECTORS

A. Flexible duct connection shall be made from coated fabric (or leaded vinyl if called for on the drawings). The clear space between connected parts shall be a minimum of 3" and the connection shall have 5" minimum of slack material.

2.5 FLEXIBLE PIPE CONNECTIONS

A. Flexible pipe connection shall be fabricated of multiple plies of nylon cord, fabric, and neoprene; and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongative, transverse, and angular movements.

B. The flexible connections shall be selected and specially fitted, if necessary, to suite the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected which do not require rods or cables to control extension of the connector.

C. Connectors for pipe sizes 2" or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.

D. Flexible pipe connections shall be Mason Industries Type MFTNC or MFTFU; Metraflex Twin Sphere; or Amber/Booth Type 2600 or 2655.

2.6 RESTRAINTS

A. Snubber:

1. Snubbers shall be custom fabricated using Type FN isolators mounted to steel angle brackets. The steel angle shall be sufficiently rigid and the mounting sufficiently secure to resist excessive movement of equipment during on-off cycle.

B. Thrust Restraints:

1. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be precompressed at the factory to allow for a maximum of ¼" movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable.
2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
3. Thrust restraints shall be Mason Industries Type WB, Kinetics Noise Control Type HSR, Amber/Booth Type TRK or an equal product of the manufacturer supplying the isolators.

2.7 GROMMETS

A. Grommets shall either be custom made by combining a neoprene washer and sleeve, be Isogrommets as manufactured by MBIS, Inc. (Bedford Heights, Ohio), or be Series W by Barry Controls (Watertown, Mass.). Grommets shall be sized so that they will be loaded within the manufacturer's recommended load range. Grommets shall be specially formed to prevent both from directly contacting the isolator base plate.

2.8 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this specification shall be silicone or one of the non-setting sealants indicated below:

Acoustical Sealant	D.A.P
BR-96	Pecora
Acoustical Sealant	Tremco
Acoustical Sealant	U.S.G.

PART 3 - EXECUTION

3.1 APPLICATION

A. General:

1. Refer to SECTION 2 - PRODUCTS of this specification for vibration isolation devices identified on the drawings or specified herein.
2. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

3. Reference Section 230549 for seismic requirements.

B. Major Equipment:

1. Unless otherwise shown or specified, all floor-mounted major equipment shall be set on 4" high concrete housekeeping pads. See architectural or structural drawings for details.
2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as scheduled on the drawings or specified hereunder.
3. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and wherever else shown on the drawings.
4. Flexible pipe connections shall be installed at all pipe connections to vibration-isolated equipment in the positions shown on the drawings.
5. Thrust restraints shall be installed on all floor-mounted fans developing 4" or more of static pressure, all suspended fans developing 2" or more static pressure, and wherever else called for on the drawings.
6. Snubbers shall be installed as called for on the drawings.

C. Miscellaneous Mechanical Equipment:

1. Miscellaneous pieces of mechanical equipment such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks, and expansion tanks which are connected to isolated piping system shall be vibration isolated from the building structure by Type NP or Type HN isolators (selected for 0.1" static deflection) unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

D. Pipes:

1. All chilled water, condenser water, heating water, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:
   a. Within mechanical rooms.
   b. And within 50' total pipe length of connected vibration-isolation equipment (chillers, pumps, air handling units, pressure reducing stations, etc.):
2. Piping shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than ½" Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to ½", Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least ¼" static deflection.
4. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections on all piping connected to all isolated equipment and wherever shown on the drawings.

3.2 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolation Mounts:

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases, which are parallel to equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called to herein.
4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beam joists. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360º about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze, which is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and non-isolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide ¼" clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the

equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.

2. Unless otherwise indicated, there is to be a minimum operating clearance of 1" between inertia bases or steel frame bases and the floor beneath the equipment. Position isolator mounting brackets and adjust isolators so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

D. Flexible Duct Connections:

1. Sheet metal ducts and plenum opening shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections:

1. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Restraints:

1. Snubbers shall be adjusted to clear the equipment base and to provide lateral restraint during on-off cycling, but be out of contact during normal operation of the equipment.
2. Thrust restraints shall be attached at the centerline of thrust and symmetrically on each side of the unit. The two rods of the thrust restraint shall be axially aligned. This may require modified brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Resilient Penetration Sleeve/Seals:

1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.
   a. At minimum, provide resilient penetration seals at all Mechanical, Equipment and Fan Room Penetrations.

3.3 ISOLATOR SCHEDULE

UNIT	ISOLATOR TYPE	MINIMUM STATIC DEFL.(IN.)	BASE TYPE	REMARKS

UNIT	ISOLATOR TYPE	MINIMUM STATIC DEFL.(IN.)	BASE TYPE	REMARKS
Air Handling Units	FSN (Note 1)	1.5		Thrust restraints if internally isolated.
Rooftop Air Handling Units	BC-1	1.5	BC-1	
Inline Fans	HSN	2		
Fan Coil Units	(Note 2)	(Note 2)		
Chillers	FNC	0.35		Slab on Grade
Pumps (Inline)	HSN	0.75		
Pumps (Basemount)	BIB (Note 3)	1.5		
Cooling Tower	FSNTL	2.5		
Boiler	FN	0.35		
Utility Fans	FSNTL	2		

Notes:

1. External isolator may be omitted if units have internally isolated fans and no other rotating or reciprocating components.
2. Isolators for fan coil units should be either HSN with 0.75” minimum static deflection or be equivalent to Mason Industries Type HN with 0.35” minimum static deflection.
3. For slab-on-grade installations isolators are not required. Refer to Section 23 21 23.

END OF SECTION 230548

SECTION 23 0549 - SEISMIC RESTRAINTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Locate, select, design, and install seismic restraints for all mechanical systems. Include restraints for ductwork, piping and equipment.

1.2 CODES, STANDARDS

A. Comply with the requirements of the 2015 International Mechanical Code.

B. Refer to, and comply with, the seismic design data on structural drawing sheet S100.

C. Design seismic restraint systems for Seismic Design Category listed on sheet S100..

1.3 SUBMITTALS

A. Submit manufacturer's data for all manufactured restraints.

B. Submit shop drawings for all fabricated restraints.

C. Show restraint type and location on the sheet metal and piping shop drawings.

D. Provide an affidavit signed by a registered Washington, DC structural engineer certifying that all mechanical systems requiring such have been properly engineered and designed for applicable Seismic Design Category.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Design Basis: Mason

1. Other Acceptable Manufacturers:
    a. California Dynamics Corporation
    b. M.W. Sausse and Company, Inc.
    c. Vibration Mounting and Controls, Inc.
    d. Kinetics
    e. Vibro-Acoustics
    f. By prior approval

PART 3 - EXECUTION

3.1 GENERAL NOTES FOR BRACING OF DUCTS

A. Details shown in the Guidelines provide a lateral bracing system. A typical vertical support system conforming to the standards must also be used. However, where bracing occurs, the required vertical angle may replace a typical vertical support. This includes a trapeze vertical supporting system.

B. Brace all rectangular ducts 6 sq. ft. of area and larger. Brace all round ducts 38” in diameter and larger.

C. Transverse bracing to occur 30’ - 9” o.c. maximum. (Except rectangular ducts 61” and larger in either direction may be braced at 32’ - 0” o.c.) Transverse bracing shall be installed at each duct turn and at each end of a duct run.

D. Longitudinal bracing shall occur at 60’ - 9” o.c. maximum. Transverse bracing for one duct section may also act as longitudinal bracing for a duct section connected perpendicular to it, if the bracing is installed within four feet of the intersection of both ducts and bracing is sized for the larger duct. Duct joints shall conform to SMACNA duct construction standard. All joints in duct sections shall provide a positive fastening together of the section.

E. No bracing is required if the top of duct is suspended 12” or less from the supporting structural member and attached to top of duct.

F. A group of ducts may be combined in a larger size frame using the overall dimensions with total maximum weight for selection of the framing members.

G. Walls (including gyp-board non-bearing partitions) which have ducts running throughout them may replace a typical transverse brace. Provide solid blockings around duct penetration at stud wall construction.

H. Ducts and pipes not braced shall be installed with a 6” minimum clearance to vertical ceiling hanger wires.

I. All sheet metal for bracing to be F(y) = 33 ksi.

J. Minimum U.S. Standards gauge for sheet metal for bracing to be as follows:

16 gauge (0.0598 inch)
14 gauge (0.0747 inch)
12 gauge (0.1046 inch)

K. It is the responsibility of the Contractor to ascertain that an appropriate size device be selected for each individual piece of equipment.

3.2 GENERAL NOTES FOR BRACING OF PIPES

A. These Guidelines are not intended for the seismic design of the piping. Piping shall be designed with consideration given to the dynamic properties of the piping and the structure.

B. Bracing details, support details, schedules and notes listed in the Guidelines apply to all types of pipe and all types of joints.

1. Brace all pipes 2½" diameter and larger:

   EXCEPTIONS

   a. Brace all piping 1¼" and larger located in boiler rooms, mechanical equipment rooms and refrigeration machinery rooms. Bracing requirements for pipes less than 2½" in diameter shall be the same as for 2½" pipes in all other locations.
   b. Brace all fuel gas and oil piping, 1" and larger.
   c. Seismic braces may be omitted:
      1) When the top of the pipe is suspended 12" or less from the supporting structure member and the pipe is suspended by an individual hanger.
      2) On all piping ¾" and smaller.

2. Details shown in the Guidelines provide a lateral bracing system. A typical vertical support system conforming to the above standard must also be used.
   a. Vertical Piping
      1) Attachment - Vertical piping shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents. Stacks shall be supported at their bases and if over 2 stories in height at each floor by approved metal floor clamps.
      2) Screwed pipe (I.P.S.) shall be supported at not less than every other story height.
      3) Copper tubing - copper tubing shall be supported at each story for piping 1½" and smaller in diameter.
      4) Pipes of other approved material shall be supported in accordance with their approved installation standards.
   b. Horizontal Piping
      1) Supports - Horizontal piping shall be supported at sufficiently close intervals to keep it in alignment and prevent sagging.
      2) Screwed pipe - Screwed pipe (I.P.S.) or flanged pipe shall be supported at approximately 10 foot intervals.
      3) Copper tubing - Copper tubing shall be supported at approximately 6 foot intervals for tubing 1½" and smaller in diameter and 10 foot intervals for tubing 2" and larger in diameter.
      4) Pipes of other approved materials shall be supported in accordance with their approved installation standards.
3. Provide transverse bracings at 40' - 0" o.c. maximum unless otherwise noted in the Guidelines.
4. Provide longitudinal bracings at 80' - 0" o.c. maximum unless otherwise noted in the Guidelines. When thermal expansion or contraction is involved, provide longitudinal bracings at anchor points. The longitudinal braces and the connections must be capable of resisting the force induced by expansion and contraction.
5. Transverse bracing for one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 24" of the elbow or tee of similar size.
6. For threaded piping the flexibility may be provided by the installation of swing joints. In welded or solder joint piping the flexibility shall be provided by expansion loops or

manufactured flexible connectors. For piping with manufactured ball joints select length of piping offset using "Seismic Drift" in place of "Expansion Per Joint Manufacturers" selection table. Seismic Drift = 0.015 ft. per foot of height.

7. Do not use branch lines to brace main lines.
8. Trapeze hangers may be used. Provide flexibility in joints where pipes pass through building seismic or expansion joints, or where pipes pass through building seismic or expansion joints, or where rigidly supported pipes connect to equipment with vibration isolators.
9. A rigid piping system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and a roof; solid concrete wall and a metal deck with Lightweight concrete fill.
10. Provide large enough pipe sleeves through walls or floors to allow for anticipated differential movements.
11. A vertical pipe risers, wherever possible, support the weight of the riser at a point or points above the center of gravity of the riser. Provide lateral guides at the top and bottom of the riser, and at intermediate points not to exceed 30' - 0" on center.
12. Cast iron pipe of all types, glass pipe and nay other pipe joined with a shield and clamp assembly where the top of the pipe is 12" or more from supporting structure shall be braced on each side of a change in direction of 90^0 or more. Riser joints shall be braced or stabilized between floors.
13. For gas piping, the bracing details, schedules and notes may be used except that transverse bracing shall be at 20' - 0" o.c. maximum and longitudinal bracing at 40' - 0" o.c. maximum. Also 1", 1¼", 1½", and 2" diameter pipes shall be braced the same as 2½" diameter pipe in the schedule. (No bracing is required for pipes ¾" diameter and smaller).
14. Proprietary bracing systems approved by OSA may be used in lieu of the braces shown in the details.

C. The seismic bracing and support of fire protection piping is not part of the bluelines. Such piping shall be braced in accordance with NFPA 13 and 14 as applicable.

D. It is the responsibility of the user of the contractor to ascertain that an appropriate size device be selected for each individual piece of equipment.

E. Essential facilities or life safety equipment. "Essential facilities" mentioned in the Guidelines are those structures or buildings which must be safe and useable for emergency purposes after an earthquake in order to preserve the health and safety of the general public.

3.3 GENERAL NOTES FOR EQUIPMENT RESTRAINTS

A. Mechanical Equipment Anchorages such as bolts, expansion anchors, screws, etc., shall comply with the force level requirements of the above standards as well as the International Building Code.

B. Restraining Devices shall be designed to conform with the force level requirements of A above.

C. Restraining Devices must be placed on all sides of the equipment base.

D. It is the entire responsibility of the Equipment Manufacturer to design his equipment so that the strength and anchorage of the internal components of the equipment exceeds the force level used to restrain and anchor the unit itself to the supporting structure.

E. It is the responsibility of the Mechanical Contractor to ascertain and assure that an appropriate size device be selected for each piece of equipment (including whole unit restraints for internally braced equipment).

END OF SECTION 230549

SECTION 23 0553 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Plastic Pipe Markers and method of application.
2. Engraved Plastic Laminate Sign.

B. LEED:

1. Adhesives and Sealants:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standard: South Coast Air Quality Management District (SCAQMD) Rule #1168, July 1, 2005 and Green Seal Standard for Commercial Adhesives GS-36, October 19, 2000.
2. Low-Emitting Paints and Coatings:
   a. Submit product data or other published information verifying the VOC (Volatile Organic Compound) content is less than or equal to the allowable VOC content established by the governing standards: Green Seal Standard GS-11, Paints, First Edition, May 20, 1993; Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997; South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, January 1, 2004.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide manufacturer's standard products.

B. Where more than a single type is specified for an application, selection is Installer's option, but provide a single selection for each application.

2.2 PLASTIC PIPE MARKERS (TYPE A)

A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, color-coded, plastic-sheet pipe markers, complying with ANSI A13.1.

B. For Pipes Less Than Six Inches (including insulation if any): Provide full-band pipe markers, extending 360º around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.

3. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than ¾" wide; full circle at both ends of pipe marker, tape lapped 1-½".

C. For Pipes Six Inches and Larger (including insulation if any): Provide either full-band or strip-type markers, but not narrower than 3 x letter height, taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-½" wide; full circle at both ends of pipe marker, tape lapped 3".

D. Lettering: Manufacturer's pre-printed wording which conforms to contract document system descriptions.

E. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering or as a separate unit of plastic (to accommodate both directions).

2.3 STENCILING (TYPE B)

A. Using a color contrasting to the surface to identify, spray or brush paint through neatly cut stencils.

B. Lettering shall conform to wording on contract documents. Size shall be in accordance with ANSI A13.1.

2.4 BACKGROUND COLOR AND STENCILING (TYPE C)

A. In addition to the requirements above, paint a background color band in accordance with ANSI A13.1.

2.5 VALVES TAGS

A. Plastic Valve Tags: Provide manufacturer's standard solid white plastic valve tags with printed black enamel lettering, with piping system abbreviation in approximately 3/16" high letters and sequenced valve numbers approximately 3/8" high, and with 5/32" hole for fastener..

2.6 VALVE SCHEDULE

A. Provide schedule for each piping system, as defined on the drawings, and below, typewritten and reproduced on 8-½" x 11" bond paper.

B. Tabulate valve number, piping system, system legend (as shown on tag), location of valve (room or space), and variations for identification (if any).

C. Provide piping schematic for each system as defined below in Part 3.

D. In addition to mounted copies, furnish extra copies for maintenance manuals as specified.

E. Valve Schedule Frames: For each page of the valve schedule, provide a glazed frame, with screws for removable mounting on masonry walls.

2.7 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, 1/16" thick, black with white core (letter color).

B. Fastening:

1. Screws
2. Rivets
3. Permanent Adhesive

C. Lettering and Graphics:

1. Coordinate names, abbreviations and other designations used in the mechanical identification work, with the corresponding designations shown, specified or scheduled in the construction documents.
2. In addition, for heating or cooling units and exhaust fans, identify area served.

PART 3 - EXECUTION

3.1 GENERAL

A. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, install identification after completion of covering and painting.

B. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION

A. **General:** Identify air supply, return, exhaust, intake and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow, in black or white, whichever provides most contrast with ductwork color.

B. **Location:** In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacing along exposed runs.

C. **Access Doors:** Provide stenciled or plastic laminate type signs on each duct or equipment mounted access door in ductwork and housings, indicating the purpose of the access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

3.3 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers on piping of the following systems and include arrows to show normal direction of flow.

1. Domestic water piping (hot, cold, tempered; 120º hot, 180º hot, hot water recirculating, etc.).
2. Plumbing vent and sanitary (above grade) piping.

3. Storm piping.
4. Heating water piping (supply and return).
5. Chilled water piping (supply and return).
6. Natural gas piping, (indicate pressures).
7. Condenser water (supply and return).
8. Refrigerant piping (suction, liquid, hot gas bypass).
9. Compressed air piping (indicate pressure).
10. Boiler system piping (make-up, condensate, vent, chemical treatment).
11. Deionized water piping.
12. Fire protection. See Section 21 10 00 for required nomenclature and spacing of labels.
13. Any other piping system as indicated on the drawings, or as required to match existing.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces above accessible ceilings, in accessible maintenance spaces, including chases, and above ceiling:

1. Near each valve and control device.
2. Near each branch, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where there could be a question of flow pattern.
3. Near locations where pipes pass through walls, floors, or ceilings, or enter non-accessible enclosures.
4. Near major equipment items and other points of origination and termination.
5. Spaced intermediately at maximum spacing of 50’ along each piping run.
6. Within 6’ of access doors above otherwise non-accessible ceilings and chases.

C. Type:

1. Normally exposed to view - Type A or C.
2. Normally concealed from view - Type B.

3.4 VALVE IDENTIFICATION

A. Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory fabricated equipment units, plumbing fixtures faucets, hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.

B. Mount framed valve schedules with piping schematics where directed by Architect.

C. Identify each valve tagged on as-built drawings.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

A. Install an engraved plastic laminate sign on or near each scheduled item of mechanical equipment.

B. Provide engraved plastic laminate nameplate on every new piece of equipment not already provided with one in accordance with Section 23 05 02 of the specifications.

C. Identify area served, if applicable.

3.6 NON-POTABLE WATER IDENTIFICATION

A. Provide an engraved plastic laminate sign.

1. Legend: “Non-Potable Water”.
2. Location: At each outlet of piping downstream of backflow preventer, (e.g. Boiler Room hose bibb).

END OF SECTION 230553

SECTION 23 0593 - TEST-ADJUST-BALANCE

PART 1 - GENERAL

1.1 RESPONSIBILITY

A. The Balancing Contractor shall be a sub-contractor, directly working for the General Contractor.

B. The Balancing Contractor shall not be a sub-contractor of any other Division 21, 22 or 23 Contractor.

1.2 QUALITY ASSURANCE

A. Qualification:

1. Work shall be done by a firm certified by the National Environmental Balancing Bureau (NEBB), or the Associated Air Balance Council (AABC), or the firm shall have technicians certified by the "National Training Fund Sheet Metal & Air Conditioning Industry".
2. The firm shall be an independent testing and balancing form specializing in testing and balancing of environmental systems.
3. The firm shall have an experience record of not less than five (5) years experience in the TAB industry.

B. Industry Standards: Comply with the following:

1. HVAC Systems-Testing, Adjusting, Balancing published by Sheetmetal and Air Conditioning Contractors National Association, Inc. (SMACNA).
2. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems published by National Environmental Balancing Bureau. (NEBB).
3. ASHRAE Systems Handbook. Testing, Adjusting and Balancing.

C. Registration: Work shall be done under the supervision of a professional engineer registered in District of Columbia. Engineer shall be available for all meetings and interpretation of all materials in the report.

D. Pre-qualification of TAB Contractor.

1. The firm must have experience and qualifications satisfactory to the consulting mechanical engineer and must be accepted by him prior to bidding.
2. Firms desiring approval to provide work under this section shall submit a booklet indicating procedures and data forms that they would use in the performance of the work.
3. Submittals shall be in accordance with Section 200101.
4. Only firms which have been approved by the mechanical engineer prior to bid date may provide work under this section.

PART 2 - PRODUCTS

2.1 PRODUCTS (Not applicable)

PART 3 - EXECUTION

3.1 GENERAL

A. Sequence work to commence after completion of system and start-up procedures and schedule completion of work before Substantial Completion of Project.

B. Examine the installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable.

C. Notify the Contractor in writing of conditions detrimental to the proper completion of the test-adjust-balance work.

1. Do not proceed with the work until unsatisfactory conditions have been corrected.
2. Provide Engineer/Architect with a copy of the notification.

D. Adjust air flows and heating water systems to within 10% of values shown. Adjust chilled water systems to within 5% of values shown. If design flows cannot be obtained within specified limits the Balancing Contractor will perform the following (at the minimum):

1. Measure and record major pressure drops in the system.
2. Consult with the Engineer and Installer as required.
3. Upon receiving written directions to proceed and after any corrections are performed, re-balance affected portion of system.

E. Optimization: Work closely with the Section 23 09 00 contractor to optimize setpoints.

1. Establish the minimum air static pressure or water differential pressure for variable or bypass flow system.
2. Establish the position of minimum outside air dampers, damper/valve and sequencing relays.

F. Calibration: Be responsible for calibration of flow measurement devices used as input to the temperature control system. All air systems flow measurement stations including VAV terminals shall be calibrated against a pitot tube traverse or air diffuser capture hood. Balancing contractor shall assure accuracy of all flow measurement devices or shall report on their failure to be accurate.

G. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in a manner recommended by the original Installer.

H. Make all final readings for each system at the same time, and after all adjustments have been made.

I. Mark equipment settings, including damper control positions, balancing cocks, circuit setters, valve indicators, fan speed control settings and similar controls and devices, to show final settings at completion of test-adjust-balance work.

1. Mark with paint or other suitable permanent identification material.

J. Check all new thermal overloads.

1. Identify improperly protected equipment in report.

3.2 AIR SYSTEMS

A. Scope: All air systems are to be balanced.

B. Before any adjustments are made, check for:

1. Dirty filters, coils, or air intakes
2. Duct leakage
3. Filter leakage
4. Damper leakage, or blockage
5. Equipment vibrations
6. Correct damper operation

C. Simulate a pressure drop across filters equal to that when 50% loaded with dust.

1. Check fan motor amps with clean filters and simulated loaded filters, and report.

D. Procedure:

1. Measure and report the following for all supply, return, exhaust, and outside air systems:
   a. Individual air inlets and outlets.
   b. Pitot traverses of main supply, return, exhaust and outside air ducts.
   c. Rotating valve or velocity grid traverse of coils or filters.
   d. Plot operating point on fan curve. Include compensation for effects of altitude and inlet vanes.
2. Above measurements shall be made with system in normal, full load condition.
   a. Systems with economizers shall be measured at minimum outside air and 100% outside air.
   b. Systems with 100% outside air capability or evaporative cooling sections shall be measured at maximum outside air.
   c. VAV systems shall be measured at the zone level at maximum air condition, and at the main at the system diversity condition.
3. Make main duct traverses or coil/filter traverses and report operation at all other operating conditions (as applicable).
   a. Economizer operation
   b. Unoccupied mode

c. Smoke evacuation mode
d. Pre-cool mode
e. Fail over mode
f. Two-speed fans
g. All VAV terminals driven to maximum position

4. Set fan speed such that under no condition will the motor exceed the service factor rating when operating in any of the above possible modes.
5. Measure fan motor amps in each of the above possible operating modes (clean filters).

E. Adjust Air Systems to provided proper air pressure relationships as shown by relative air quantities or as indicated on the drawings.

F. Adjust distribution system for uniform space temperatures free from objectionable drafts and noise.

1. Division 233300 to provide orifice plates or dampers where required.

G. Exchange sheaves and belts as required to adjust the rpm of all fans so they handle specified air quantity.

H. Set minimum outside air quantities.

3.3 DOMESTIC WATER SYSTEM

A. Scope: Balance all domestic hot water and hot water re-circulation systems.

B. Before any adjustments are made:

1. Check temperature control device operation (mixing valves, external temperature control devices, etc.)
2. Check rotation of pumps.
3. Adjust pressure reducing valves.
4. Verify proper operation of ASME pressure and temperature relief valves.

C. Using flow meters, adjust the quantity of water circulated by each pump and the flow in each branch of the hot water re-circulation systems.

3.4 HYDRONIC SYSTEMS

A. Scope: Balance all hydronic systems.

B. Before any adjustments are made:

1. Check temperature control valve operation.
2. Check pump rotation.
3. Adjust pressure reducing valve.
4. Remove any roughing strainer screens in systems.

C. Using system flow meters, adjust the quantity of fluid handled by each pump and supplied to each coil, piece of radiation, heat exchanger, cross-over bridge, bypass, etc., to meet design requirements.

D. Procedure:

1. Measure and report all hydronic and domestic water recirculation systems by all of the below means which are applicable.
    a. System, pump, branch, or terminal flow measuring stations.
    b. Terminal or heat exchanger pressure drop, compare to submittal data.
    c. Plot operating point on pump curve. Include compensation for effects of temperature, viscosity and density.
2. Above measurements to be made and reported at full heating/cooling load.
    a. For 3-way valve terminals/heat exchangers set bypass flow to equal coil flow.
    b. For primary/secondary systems, set crossover/bridle to have constant flow at all conditions.

3.5 DETAILED REQUIREMENTS

A. Measure, adjust and report the following:

1. Fans:
    a. Inlet and outlet pressure
    b. Air flow
    c. Fan speed
    d. Motor amps and KW
2. Ductwork Systems:
    a. Air flow at each inlet and outlet.
    b. Blade angles at all adjustable diffusers.
    c. Filter pressure drop.
    d. Outside air percentage at minimum and maximum setting.
    e. Air flow at supply, return, outside air and exhaust mains to determine total air flow.
3. Coils:
    a. Air flow.
    b. Inlet and outlet air static pressure.
    c. Inlet and outlet air temperature.
    d. Water flow.
    e. Inlet and outlet water pressure.
    f. Inlet and outlet water temperature.
    g. Kw draw on electric coils.
4. Pumps:
    a. Water flow
    b. Inlet and outlet pressure
    c. Motor amps and KW
5. Radiation and Convectors:
    a. Inlet and outlet water temperature
    b. Air temperature (room)
    c. Water flow

6. Heating and Domestic Hot Water Boiler(s): Check at full fire.
   a. Inlet and outlet water temperatures
   b. Water flow
   c. Stack temperatures
   d. Gas pressure and cubic feet of gas per hour Percent CO_2 and O_2
   e. Combustion efficiency
   f. If boiler is equipped for variable firing rates, include data for a. through e. for maximum and minimum firing rates.
   g. Manufacturer's start-up report may be substituted if all above measurements are included.
7. Cabinet Heaters, Unit Heaters:
   a. Entering air temperature
   b. Leaving air temperature
   c. Inlet and outlet water temperature
   d. Water flow
8. Unit Ventilators:
   a. cfm
   b. Entering air temperature
   c. Leaving air temperature
   d. Inlet and outlet water temperature
   e. Water flow
   f. Outside air percentage
9. Air-Cooled Condensing Units:
   a. Ambient temperature
   b. Suction and discharge pressure
   c. Oil pressure
   d. Compressor amps and KW
   e. Fan amps and KW
10. Packaged Air Conditioning Units:
   a. Perform tests for individual components present in units in accordance with specific requirements above.
   b. At full heat: (Check at minimum outside air):
      1) EAT
      2) LAT
   c. At full cooling: (Check at minimum outside air):
      1) EAT (DB/WB)
      2) LAT (DB/WB)
      3) Ambient temperature
      4) Suction and discharge pressures
      5) Oil pressure
      6) Compressor amps and KW
11. Furnaces and Gas Fired Heaters:
   a. Air flow
   b. Inlet and outlet temperature
   c. Inlet and outlet static pressure
   d. Gas pressure
   e. Flue temperature
   f. Fan amps and voltage
12. Chillers:

a. Inlet and outlet water temperature and pressure
b. Water flow
c. Suction pressure
d. Compressor amps and KW

13. Cooling tower:
    a. Inlet air wet bulb
    b. Entering and leaving water temperatures
    c. Water flow
    d. Fan amps and voltage
14. Heat Exchangers:
    a. Cooler fluid inlet and outlet temperatures
    b. Cooler fluid flow
    c. Warmer fluid inlet and outlet temperatures
    d. Warmer fluid flow

3.6 REPORT

A. Provide a general information sheet listing:

1. Instruments used:
    a. Most recent calibration date.
2. Method of balancing.
3. Altitude correction.
4. Manufacturer's performance data for all air devices used.

B. Provide data sheets for all equipment, including motors and drives, listing:

1. Make
2. Size
3. Serial number
4. Capacity Rating
5. Amperage
6. Voltage input
7. Thermal heater size for each motor
8. Operating speed of driver and driven devices
9. Any additional pertinent performance data

C. Include design and final values for all items listed in Detailed Requirements, and totals for each system.

D. Provide data sheets showing:

1. Air flow at each inlet and outlet
2. Instrument used
3. Velocity reading
4. Manufacturer's free area factors

E. Provide recap sheet with explanation for each device not meeting specified performance.

F. Provide a set of prints with equipment, inlets and outlets marked to correspond to data sheets.

3.7 VERIFICATION

A. Upon completion of the TAB work the balancing firm shall demonstrate fluid flow quantities indicated in a preliminary TAB report.

1. The TAB representative shall be a member of the same team used during the original testing.
2. Equipment used during the random testing shall be the same equipment used during the original testing.
3. The system or equipment being verified shall be in the same operating mode as during the original TAB test.
4. Up to 10% of the air readings shall be re-tested. Ninety percent (90%) of the re-tested readings must be within tolerances of the specifications.
5. Up to 10% of the balanced heating hydronic component readings shall be re-tested. Ninety percent (90%) of the re-tested readings must be within tolerances of the specifications.
6. Up to 20% of the balanced chilled water component readings shall be re-tested. Ninety percent (90%) of the re-tested readings must be within tolerances of the specifications.
7. Whenever system verifications do not meet these specifications the entire system shall be re-balanced and rechecked.

3.8 COMMISSIONING

A. Reference Section 23 08 00 for commissioning scope.

B. Provide all necessary personnel, tools and equipment to comply with the commissioning scope.

END OF SECTION 230593

SECTION 23 0700 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Insulation.
2. Jackets, coatings and protective finishes.
3. Sealers, mastics and adhesives.
4. Fitting covers.
5. Manufacturer's installation details for fire rated duct wrap.
6. Low-Emitting Adhesives and Sealants EQc4.1 requirements for LEED submittals.

1.2 FLAME AND SMOKE RATINGS

A. Provide insulation tested on a composite basis (insulation, jacket, covering, sealer, mastic and adhesive) complying with the following:

1. Flame Spread: 25 or Less
2. Smoke Developed: 50 or Less
3. Method: ASTM E84 (NFPA 255)

1.3 PRODUCT DELIVERY

A. Deliver insulation products in factory containers bearing manufacturer's label showing fire hazard rating, density and thickness.

1.4 DEFINITIONS

A. Exposed Location: Located in mechanical rooms or other areas exposed to view.

B. Concealed Location: Located in pipe chases, furred spaces, attics, crawl-spaces, above suspended ceilings, or other locations not exposed to view.

1.5 STANDARDS

A. Comply with the latest edition of National Commercial and Industrial Insulation Standards.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

A. Manufacturers:

1. Design Basis: Johns-Manville

2. Other Acceptable Manufacturers:
   a. Armstrong
   b. Foster
   c. Owens-Corning
   d. Knauf
   e. Nomaco
   f. Imcoa
   g. Pittsburgh Corning
   h. Cell-U-Foam

B. Materials:

1. Fiberglass Pipe Insulation: Johns-Manville Micro-Lok heavy density pipe insulation with AP-T jacket.
2. Fiberglass Pipe Fitting Insulation: Johns-Manville "Zeston" fitting covers with factory-cut fiberglass insulation insert.
3. Flexible Unicellular Pipe Insulation: Armstrong Armaflex, II or Therma-cel By Nomaco.
4. Cellular glass with vapor barrier coating: Pittsburgh Corning.
5. Rigid Closed Cell Insulation: Dow Trymer 2000 (not for use indoors).

C. Insulation thickness and conductivity: (Thickness and conductivity listed below are minimum required. Provide thickness and conductivity required by Local Building or Energy Codes).

1. Service (Domestic) Water Piping:
   a. Hot, 140ºF and under: (Insulation conductivity: 0.21–0.28 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1-½": 1"
      2) Sizes 1-½" and larger: 1-½":
      3) Runouts up to 2" and 8 feet long: 1"
   b. Cold, 40ºF to 60ºF: (Insulation conductivity: 0.21–0.27 (Btu x in.)/(h x ft^2 x ºF))
      1) All pipe sizes: 1"
2. Heating Hot Water
   a. 140ºF and under: (Insulation conductivity: 0.21–0.28 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1-½": 1"
      2) Sizes 1-½" and larger: 1-½":
      3) Runouts up to 1" and 4 feet long, to terminal units: 1"
   b. 141ºF to 200ºF: (Insulation conductivity: 0.25–0.29 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1-½": 1-½"
      2) Sizes 1-½" and larger: 2"
      3) Runouts up to 1" and 4 feet long, to terminal units: 1"
   c. Under 15 psig or 201ºF to 250ºF: (Insulation conductivity: 0.27–0.30 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 4": 2-½"
      2) Sizes 4" and larger: 3"
   d. 15 to 125 psig or 251ºF to 350ºF: (Insulation conductivity: 0.29–0.32 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1": 3"
      2) Sizes larger than 1" and smaller than 1-½": 4"
      3) Sizes 1-½" and larger: 4-½"
   e. Over 125 psig or 350ºF: (Insulation conductivity: 0.32–0.34 (Btu x in.)/(h x ft^2 x ºF))

1) Sizes smaller than 1": 4-½"
2) Sizes larger than 1": 5"

3. Chilled Water, Brine and Refrigerant:
   a. 40ºF to 60ºF: (Insulation conductivity: 0.21–0.27 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1-½": ½"
      2) Sizes 1-½" and larger: 1"
      3) Runouts up to 1" and 4 feet long, to terminal units: 1"
   b. 40ºF and under: (Insulation conductivity: 0.20–0.26 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1": ½"
      2) Sizes 1" and larger but smaller than 8": 1"
      3) Sizes 8" and larger: 1-½"
      4) Runouts up to 1" and 4 feet long, to terminal units: 1"
4. Condenser Water:
   a. 40ºF to 60ºF: (Insulation conductivity: 0.21–0.27 (Btu x in.)/(h x ft^2 x ºF))
      1) Sizes smaller than 1-½": ½"
      2) Sizes 1-½" and larger: 1"
5. Storm Water:
   a. All Sizes: 1"
6. Refrigerant Suction and Hot gas Bypass Lines:
   a. Size 2-1/8" and smaller: ½"
   b. Size 2-5/8" and larger: ¾"
7. Refrigerant Liquid Lines:
   a. All Sizes: ½" (1" for fiberglass)
8. Solar Collector Supply and Return Piping:
   a. Inside House: ½"
   b. Below Grade: ½"
   c. All Other: 1"
9. Repairs to Existing Insulation: Match thickness of existing insulation.
10. All Heat Traced Piping: (Insulation conductivity: 0.27 or less (Btu x in.)/(h x ft^2 x ºF))
    a. Size 2" and smaller: 1"
    b. Size 2½" and larger: 2"
11. Condensate Drain Piping:
    a. All sizes: ½" (1" for fiberglass)
12. Acid Waste/Vent:
    a. All sizes: 1"
13. PVC pipe in plenums or above noise sensitive areas:
    a. All sizes: See Part D.

D. Application: Unless otherwise indicated, use the following:

1. Inside, above ground: Fiberglass.
2. Inside exposed: Fiberglass with PVC jacket (jacket not required in mechanical rooms).
3. Outside building envelope: Rigid closed cell with aluminum jacket.
   a. Provide sealant at all point joints to maintain vapor barrier.
   b. Sealant shall be per insulation manufacturer recommendation.
   c. Sealant submittal shall include a letter from the insulation manufacturer verifying that proposed sealant is compatible with insulation.
4. Below grade or slab:
   a. Pipe size 1½" and less: Single piece of flexible closed cell insulation slipped over soft annealed copper tube without slitting insulation.

b. Pipe size 2" and larger: Rigid closed cell insulation with shrink fit jacket.

5. PVC: 1½" thick fiberglass (duct) insulation, or 1" heavy density pipe insulation installation to meet ASTM E84 (NFPA 255) flame spread and smoke developed ratings.
6. Acid waste/vent in return air plenums: Flexible unicellular insulation.
7. Refrigerant and condensate drain piping: Flexible unicellular or fiberglass insulation.

2.2 DUCT INSULATION

A. Manufacturer:

1. Design Basis: Johns Manville
2. Other Acceptable Manufacturers:
   a. Certainteed
   b. Knauf
   c. Owens-Corning

B. Materials:

1. Flexible Faced fiberglass Ductwork Insulation: Johns-Manville Microlite, with FSK factory applied foil-scrim-kraft facing.
2. Rigid Fiberglass Ductwork Insulation: Johns-Manville 800 Series, Spin-Glas Type 814, 3 lb. Density rigid board with FSK jacket.
3. Flexible Plain Fiberglass Ductwork Insulation: Johns-Manville Microlite .75 lb/cu. Ft. unfaced.
4. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles, and similar accessories as recommended by the insulation manufacturer for the applications indicated.
5. Cellular glass: Pittsburgh Corning with vapor barrier.

C. Application:

SYSTEM	EXPOSED	CONCEALED	OUTDOOR	ARENA BOWL
Supply	1 ½" liner	1 ½" liner	1 ½" liner + 1" exterior wrap (Note 4)	Double wall insulated with perforated inner wall
Return	1 ½" liner	1 ½" liner	1 ½" liner +1" exterior wrap (Note 4)	N/A
Exhaust	None	None	1" exterior wrap (Note 4)	N/A
Outside Air	1" rigid	1 ½" wrap	1" rigid + 1" exterior wrap (Note 4)	N/A

1. Reference 23 07 00/ Duct Insulation and 23 31 13/ Duct Liner.
2. Where energy codes require additional insulation over that listed above, provide insulation in accordance with those codes.
3. Insulate all accessories and components (fire dampers, silencers, air valves, etc.) of the duct systems noted above as requiring insulation. Where lined systems contain

components that cannot be lined or have not been provided with liner, insulate them. That insulation shall overlap the lined portion of the system by at least 12 inches.

4. Build up and pitch insulation to prevent water ponding on rectangular ductwork 36” or greater in width.
5. Round ducts concealed above ceilings and serving individual terminal units or diffusers may be wrapped in lieu of liner.

D. Duct Liner:

1. See Section 23 31 13, for duct liner requirements. Supply, return and outside air ductwork that is not lined is to be externally insulated.

2.3 OUTDOOR DUCT INSULATION

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
   a. Johns-Manville
   b. Nomaco

B. Materials:

1. Model: Armaflex
   a. Description: Flexible, cellular, elastomeric foam.
   b. Form: Sheet
2. Paint: Armaflex Finish
   a. Description: White vinyl lacquer. If duct is visible from the ground, contractor must first coordinate color of vinyl lacquer with Architect. Submit color chart to Architect for his review.
3. Adhesive: Armstrong 520.
4. Cellular glass: Pittsburgh Corning with vapor barrier.

C. Application: Refer to Application Schedule.

2.4 EQUIPMENT INSULATION

A. Manufacturer:

1. Design Basis: Johns Manville
2. Other Acceptable Manufacturers:
   a. Armstrong
   b. Certainteed
   c. Owens-Corning
   d. Knauf
   e. Pittsburgh Corning

B. Materials:

1. Model: Pipe and tank insulation.

Description: Flexible board type insulation. 3 PCF glass fiber insulation with all-purpose jacketing. Maximum thermal conductivity .32 BTU-IN/ (hr-FT^2-ºF) at 150ºF. Glass fibers oriented such that insulation will conform to rounded shapes while maintaining high compressive strength.

2. Model: Johns-Manville 800 series, spin glass type 814.
   Description: 3 PCT density rigid glass fiberboard, with all-purpose jacketing. Maximum thermal conductivity .27 BTU-IN/hr-FT^2--ºF).
3. Jacketing Material: PVC or aluminum jacketing material, except as otherwise indicated. Seal all joints.
4. Fiberglass: Johns-Manville Micro-Lok 850 insulation with APT jacket.
5. Flexible Unicellular Insulation: Armstrong Armacell sheet form.
6. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors, stud pins, metal covers, adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

2.5 BOILER BREECHING AND ENGINE EXHAUST INSULATION

A. Application:

1. Breeching insulation is required only if the Contractor exercises his option to use welded steel breeching instead of double wall vent pipe in the boiler room.
2. Double wall vent pipe need not be insulated.
3. All generator exhaust piping, muffler and related components shall be insulated.

B. Materials:

1. Manufacturers:
   a. Design Basis: Johns-Manville
   b. Industrial Insulation Group IIG
   c. Other Acceptable Manufacturers:
      1) U.S. Gypsum
2. Description:
   a. Thermo-12 gold calcium silicate ASTM C533, Type I.
   b. Compressive Strength: min 100 psi to produce 5% compression.
   c. Maximum Service Temp: 1200 F
3. Thickness: Two inches.
4. Jacketing Material: 0.016 Aluminum with moisture barrier.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify acceptability of all materials which are to be used in air plenums (above ceiling, etc.). Materials must meet all requirements of Local Building Code and Authority having jurisdiction.

3.2 PIPE INSULATION

A. Insulate the following:

1. Domestic hot water piping.
2. Domestic cold water piping above ground and under slab.
3. Heating piping.
4. Chilled water piping.
5. Roof drain bodies and all horizontal storm water piping.
6. Refrigerant suction lines.
7. Condensate drain piping.
8. Heat traced piping.

B. Installation:

1. Install insulation on pipe system subsequent to testing and acceptance of tests.
2. Install insulation materials with smooth and even surfaces.
    a. Insulate each continuous run of piping with full length units of insulation, with a single cut piece to complete the run.
    b. Do not use cut pieces or scraps abutting each other.
3. Clean and dry pipe surfaces prior to insulating.
    a. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
4. Extend piping insulation without interruption through pipe clamps, hangers, walls, floors and similar piping penetrations, except where otherwise indicated. **Hangers and supports must be installed outside, not through, insulation.**
5. Install protective metal shields and saddles where needed to prevent compression of insulation. Refer to Section 23 05 29.
6. Except as noted, cover valves, flanges, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run.
    a. Install factory-molded, pre-cut or job-fabricated units (at Installer's option), except where a specific form or type is indicated.
    b. Do not cover:
        1) Valve operators.
    c. Provide removable access for:
        1) Strainers.
        2) Other components requiring access for service.
7. Mark location of unions and flanges covered by insulation with permanent paint or ink, or approved label.
8. Maintain integrity of vapor-barrier jackets on insulation of cold pipes and storm drainage piping, and protect to prevent puncture or other damage.
9. Insulate between pipe and pipe saddles. Provide suitable saddles.
10. Seal ends of sections with vapor barrier cement to crate moisture dams at:
    a. 21 ft. intervals.
    b. Valves and fittings.
    c. All hangers and supports.
11. On underground pipe insulation, install unicellular insulation on pipe without slitting insulation.
    a. Seal all transverse joints with adhesive.
12. Replace existing insulation removed or damaged because of work of this project.
13. Insulate new pipes and replace insulation on existing pipes to remain where insulation was removed or damaged by demolition or revisions.

14. Do not insulate basket access flange of flanged strainers.
15. Do not insulate steam traps.
16. Insulate between fingers of spiders in alignment guides.
17. Insulate between pipe and pipe slide.
18. Perform all work in a neat and workmanlike manner. Poor work (as determined by Architect or Engineer) will be cause for rejection.
19. Insulate all acid waste/vent pipe in return air plenums with Armstrong AP Armaflex.
20. Provide PVC jacket for all exposed, insulated piping within food service areas.

3.3 UNDERGROUND HYDRONIC PIPE INSTALLATION

A. Portions of the chilled and heating water piping system shall be insulated below grade.

B. The installed piping system shall have the following characteristics.

C. Insulating Value: The system shall provide a conductivity of 0.165 Btu-in/hr ft^2 F^o at 75ºF (r-value of 6).

1. The insulation shall be Foamglass Pittwrap SS II, waterproof (not lose insulating value when saturated with liquid water or completely sealed against the introduction of water) and 2" thick.
2. The exterior of the pipe shall be completely sealed against the introduction of moisture when the system has been installed in ground water saturated fill.
3. The system shall be compatible with the excavation and backfilling methods and materials used.
4. The system shall be able to sustain medium duty tract loading (1000 lb wheel loading at the surface) without damage.

D. Minimum burial depth shall be 5'-0" below finished grade.

E. The actual system used shall be at contractor's option as long as the above criteria is met, and may be a pre-fabricated or field built system. However, if the system submitted by the Contractor does not meet this criteria (as determined by Engineer), the Contractor shall supply a double pipe pre-fabricated system equivalent to that manufactured by Ricwil or Perma-Pipe.

3.4 OUTDOOR PIPE INSULATION

A. Install rigid cellular glass insulation with butt joints of half pipe sections staggered. Insulation shall be held in place with strapping tape. Install aluminum jacket with all joints lapped to shed water. Apply a bead of silicone sealant at all transverse and longitudinal seams. Secure with aluminum bands, minimum of 2 per jacket section.

B. Contractor to verify that sealant has been applied per sealant and insulation manufacturer recommendations for proper vapor barrier.

3.5 DUCTWORK INSULATION

A. Install insulation materials with smooth and even surfaces.

B. Clean and dry ductwork prior to insulating.

1. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

C. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated. **Hangers and supports must be installed outside, not through, insulation.**

D. Except as otherwise indicated, do not insulate lined ducts. However, extend duct insulation 12" beyond start of lining where lined ductwork meets insulated ductwork.

E. Maintain integrity of vapor-barrier on insulation of ducts carrying cold air, and protect it to prevent puncture and other damage.

F. For Outdoor Insulation:

1. Stagger joints on multilayer applications.
2. Locate joints at sides of ducts whenever possible.
3. Use 520 adhesive to attach insulation.
   a. Use full coverage.
4. Seal all seams and joints with adhesive.
5. Maintain full thickness at standing seams and flanges by additional layer(s).
6. Cover flexible connections.
7. Extend covering to inside face of outside wall.
8. Finish with two coats of Armaflex finish.

3.6 EQUIPMENT INSULATION

A. Install insulation materials with smooth and even surfaces and on clean and dry surfaces.

1. Re-do poorly fitted joints.
2. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

B. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

C. Apply insulation using the staggered joint method for both single and double layer construction, where feasible.

1. Apply each layer of insulation separately.

D. Do not insulate handholes, cleanouts, ASME stamp and manufacturer's nameplate.

1. Provide neatly beveled edge at interruptions of insulation.

E. Chilled Water Pumps:

1. Do not insulate. Provide drain pan and drain to collect condensate formed on pump body. Pipe drain line to nearest floor drain and provide air gap.

F. Hot Equipment (Above Ambient Temperature):

1. Includes hot and heating water as well as steam equipment such as air release tanks, air separators, expansion tanks, flash tanks, vessels etc.
2. Insulate with 3" thick fiberglass.
3. Do not apply insulation to equipment while hot.

G. Heat Exchanger:

1. Cover top and both sides of exchanger wit 24 gauge galvanized steel panels with ½" flexible unicellular insulation cemented to the inside of the panels.
2. Panels shall be easily removable and easy to re-install.
3. Adhere flexible unicellular insulation to end plates with Armstrong No. 520 adhesive.

H. Domestic Water Tanks:

1. Insulate domestic hot water tanks with 2 inches of pipe and tank insulation of 1½ inches of rigid fiber glass board (if not originally insulated from the factory).

I. Cold Equipment (At or below ambient equipment):

1. Includes chilled, domestic cold, condenser water system equipment such as air release tanks, air separators, expansion tanks, flash tanks, vessels, etc.
2. Insulate air release tanks (air separators) with 2 inches of pipe and tank insulation or 1½ inches of cellular glass.

3.7 BREECHING

A. Coat insulated surfaces with layer of insulating cement, troweled to a smooth continuous surface.

B. Fill-in scored block, seams, chipped edges and depressions.

1. Cover-over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

C. Cover insulated surfaces with glass cloth jacketing neatly fitted and firmly secured.

1. Lap seams at least 2".

D. Avoid applying insulation to hot breechings and stacks.

3.8 ENGINE EXHAUST INSULATION

A. Remove dirt and dust and clean all surfaces.

B. Apply insulation using the staggered joint method for both single and double layer construction, where feasible.

1. Provide neatly beveled edge at interruptions of insulation.
2. Install insulation materials with smooth and even surfaces.
   a. Insulate each continuous run of piping and muffler(s) with full length units of insulation, with a single cut piece to complete the run.
   b. Do not use cut pieces or scraps abutting each other.
   c. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
3. Extend piping insulation without interruption through pipe clamps, hangers, walls, floors and similar piping penetrations, except where otherwise indicated.
4. Install protective metal shields and saddles where needed to prevent compression of or damage to insulation. Refer to Section 23 05 29.
5. Except as noted, cover valves, flanges, fittings and similar items in each exhaust piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run.
6. Insulation shall be held in place with strapping tape.
7. Position and layer insulation to allow for expansion of exhaust piping during generator operation.

C. Install aluminum jacket with all joints lapped to shed water. Apply a bead of silicone sealant at all transverse and longitudinal seams. Secure with stainless steel bands, minimum of 2 per jacket section.

3.9 FIRE RATED DUCT WRAP

A. Remove dirt and dust and clean all duct surfaces.

B. Install per manufacturer's instructions and referenced standards. Where pins are required they shall be tack welded to duct.

C. Repair any damage in accordance with manufacturer's instruction.

3.10 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily. Including units with vapor barrier damage and moisture saturation.

B. Protection: The insulation installer shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

END OF SECTION 230700

SECTION 23 0800 - BUILDING MECHANICAL SYSTEM COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplemental Conditions and Section 23 05 02 apply to all work specified in this section.

B. Refer to Specification Section 23 05 93, title "Test and Balance" for interface requirements with test and balance contractor.

1.2 DESCRIPTION OF WORK

A. This specification covers the start-up, operating performance test and commissioning of the HVAC systems. The purpose of this effort is to bring the project mechanical systems to a state of dynamic operation in accordance with the contract documents by verifying the operation of individual components, subsystems and systems.

B. The Owner will retain the services of an independent commissioning agent (CA) separate from the work of this Contract. As herein specified the Owner and CA shall develop detailed commissioning procedures, equipment checkout procedures and data forms for recording compliance with contract documents, performance and punchlist deficiencies, and will assist in developing schedules for checkout and Owner acceptance, at a future date during the construction phase.

C. The Division 23 Mechanical Contractor and the General Contractor shall include as part of the work of this contract, labor and material to provide manpower, equipment, tools, ladders, instruments, etc. necessary to accomplish the work and labor and material for execution, monitoring and printing data forms necessary to verify and record system observations.

D. The Test and Balance Contractors shall include as part of the work of this contract, labor and material to provide manpower, equipment, tools, ladders, instruments, etc. necessary to execute and accomplish the work.

E. At the completion of the start-up, operations performance test and test and balance, the Contractor shall conduct a 72-hour dynamic mode demonstration of the systems in the presence of the Owner/Architect/Engineer and CA.

1.3 COMMISSIONED EQUIPMENT [List Equipment]

1.4 COMMISSIONED SYSTEMS [List Systems]

PART 2 - PRODUCTS

2.1 MATERIALS, LABOR, INSTRUMENTS, TOOLS, LADDERS AND APPARATUS

A. The Contractor shall provide all materials, labor, instruments, tools, ladders and apparatus necessary to start-up, perform operating performance test and systems conditioning.

B. The Contractor shall be responsible for maintaining the commissioning documentation until final acceptance of the project. The checklists in appendix one are samples for bidding purposes. Final checklists will be produced by the CA and provided prior to beginning commissioning. The commissioning documentation shall be kept current by the Contractor and shall be available for inspection at all times. At the time of acceptance of the project, the Contractor shall surrender 3 completed copies of the commissioning documentation to the Owner's representative.

PART 3 - EXECUTION

3.1 START-UP AND OPERATING PERFORMANCE TEST

A. Before request for contract compliance inspection and system commissioning all equipment, components, and systems shall be started-up, adjusted, calibrated; set, test and check all electric disconnect, fuses, circuit breakers, valves, dampers, temperatures and pressures of all systems for proper operation and performance. After completion of the start-up and operating performance test, the Contractor will notify the Owner in writing that the system is ready for commissioning.

B. Information, date, etc. from start-up and operating performance test may be utilized, as appropriate, to execute preliminary commissioning documentation, however, certification of equipment and systems for the preliminary commissioning phase shall be completed in accordance with paragraph 3.2 of this section of the specifications.

C. Start-up and operating performance test documentation shall include the following:

1. Rooftop Air Handling Unit Systems:
    a. Coil entering and leaving air temperature.
    b. Coil entering and leaving water temperature.
    c. Coil water pressure drop.
    d. Space temperatures at thermostats or sensors.
    e. Total fan air CFM.
    f. Selected air flow readings at major branch ducts and grilles.
    g. Fan speed.
    h. Fan total static pressure.
2. Air Handling Unit Systems:
    a. Coil entering and leaving air temperature.
    b. Coil entering and leaving water temperature.
    c. Coil water pressure drop.
    d. Space temperatures at thermostats or sensors.
    e. Total fan air CFM.
    f. Selected air flow readings at major branch ducts and grilles.
    g. Fan speed.
    h. Fan total static pressure.
3. VAV System:
    a. Box entering air temperature.

b. Space temperature at thermostats or sensors.
c. Total box air CFM minimum position and maximum position.
d. Selected air flow readings at branch ducts and grilles.
e. Static pressure entering and leaving box.

4. Fan Coil Unit Systems/Fan Powered Systems:
   a. Coil entering and leaving air temperature.
   b. Coil entering and leaving water temperature.
   c. Coil water pressure drop.
   d. Space temperatures at thermostats or sensors.
   e. Total fan air CFM.
   f. Selected air flow readings at major branch ducts and grilles.
   g. Fan speed.
   h. Fan total static pressure.
5. Ventilation/Outside Air Fans:
   a. Total fan CFM.
   b. Fan speed.
   c. Fan total static pressure.
6. Exhaust Fans:
   a. Total fan CFM.
   b. Fan speed.
   c. Fan total static pressure.
7. Coils:
   a. Entering water temperature and pressure.
   b. Leaving water temperature and pressure.
   c. Entering and leaving air temperature.
8. Heat Exchangers:
   a. Entering water temperature and pressure.
   b. Leaving water temperature and pressure.
9. Cooling Towers:
   a. Entering water temperature.
   b. Leaving water temperature.
   c. Ambient wet bulb temperature.
10. Chillers:
    a. Cooler water temperature entering and leaving.
    b. Condenser water temperature entering and leaving.
    c. Cooler water pressure entering and leaving.
    d. Condenser water pressure entering and leaving.
    e. Compressor safety and operating controls.
    f. Capacity reduction controls.
    g. Low ambient controls.
11. Electric Motors:
    a. Full load amperes and voltage.
    b. Starter heater size and rated amperage range for heater installed.
    c. Measure running current, after adjustment of system to deliver rated performance.
12. Controls:
    a. Operational setting of controllers and instruments.
    b. Positioning and function of valves and dampers.
    c. Interlock and operation of systems (HVAC and Fire)
13. Refrigeration System:
    a. Compressor safety and operating controls.

b. Capacity reduction controls.
c. Low ambient controls.
d. Condenser fan operation.

14. Pumps:
    a. Water pressure entering and leaving.
    b. Installed impeller diameter.
15. Heat Pipes:
    a. EAT and LAT temperatures on each coil.

3.2 SYSTEM COMMISSIONING

A. All systems, components, equipment, etc. furnished as part of this Contract shall be subjected to system commissioning as hereinafter specified. All systems, components, equipment, etc. commissioned in this section of the Specifications shall be evaluated based on the sequences of control/operation, performance characteristics, and equipment schedules, etc. as specified in other sections of the Specifications and as shown on the contract drawings. Systems, components, equipment, etc. that does not have specified operating sequence, etc. shall be operated and evaluated based on its use and function for this project.

B. Commissioning Documentation: The Contractor shall maintain the commissioning documentation in 3-ring binders. The commissioning documentation shall be organized by system when practicable. All pages shall be numbered and a table of contents page shall be provided. The commissioning documentation shall include, but not be limited to, the following:

1. Design Criteria provided by the A/E.
2. Approved Test and Balance Report for the system or component being commissioned, provided by Test and Balance Contractor.
3. Approved submittals for all equipment to be commissioned, provided by Mechanical Contractor.
4. All approved shop drawings of equipment to be commissioned. Shop drawings shall be full size sheets folded as required to fit in binders. Provided by Mechanical Contractor.
5. All pre-commissioning checklists initialized by indicated personnel organized by system and subsystem.
6. All functional performance test checklist initialized by indicated personnel organized by systems and subsystems.
7. Three copies of the Operation and Maintenance Manuals specified in other sections of these specifications shall be reviewed by the CA for completeness and for applicability. The manuals shall be incorporated in the Commissioning Documentation prior to the commencement of the training required in other sections of the specifications. Preparation of Operation and Maintenance Manuals shall be as specified in other sections of these specifications.

C. Shop Drawings and As-Built Drawings and Specifications shall be assembled by the Contractor after completion of the pre-commissioning phase and turned over to the Owner's representative. Changes as a result of subsequent Commissioning procedures will be incorporated (as required) at the conclusion of final Commissioning.

D. Commissioning Schedule:

1. Phase 1 - Preliminary Commissioning: All shop drawings, including but not limited to, equipment, controls, test and balance reports, and operation and maintenance manuals, shall be submitted and approved by the CA. In addition, all pre-commissioning checklists shall be completed (initialed by all parties).
2. Phase 2 - Functional Performance Testing shall be performed as indicated on the Functional Performance Test Checklists. Functional Performance Testing shall not begin until Phase 1 of the commissioning process is complete. Owner's operation and maintenance personnel shall observe the function performance testing. The Contractor may perform initial system familiarization and training of Owner's operating and maintenance personnel required under other sections of the Specification during the functional performance testing.
3. Functional Performance Test Notification: The Contractor shall notify the CA 2 weeks before functional performance testing is to begin.
4. Phase 3 - System training and operating instructions shall be conducted by the Contractor as indicated in the specifications of each item of equipment. The Contractor shall be responsible for specified training and operating instructions being observed by the CA.

E. Pre-Commissioning Checklists:

1. Pre-Commissioning Checklists shall be developed by the CA and shall be executed and certified prior to the commencement of functional performance testing. The indicated initial is required in each location for all items, except where an "X" is shown indicating an initial is not required. See initials legend below for required initials. The pre-commissioning checklist will not be accepted as complete until all items have been initialed signifying this portion of the project is ready for Functional Performance Testing. The Contractor shall provide the Ca with the completed Pre-Commissioning Checklists for his review and initials. The CA shall be the last person to initial each checklist item. The Contractor shall submit for approval a list of all contractor and subcontractor representatives responsible for the completion of the pre-commissioning checklist phase of the project. This list of representatives shall be submitted 2 weeks prior to commencement of any pre-commissioning activities of any systems or equipment. Representatives may be replaced only after written approval from the CA.
2. Initials Legend:
   a. Construction Manager.
   b. Mechanical Contractor's representative.
   c. Electrical Contractor's representative.
   d. Commissioning Agent.
   e. Balancing Contractor's representative.
   f. Controls Contractor's representative.
3. Blank Example Pre-Commissioning Checklists are in Appendix, located at the end of this section of the specifications. A separate Pre-Commissioning checklist shall be provided for each system and piece of HVAC equipment to be Commissioned.

F. Functional Performance Test Checklist:

1. Functional performance testing shall be performed by the Contractor as directed by the CA and observed by a commissioning team consisting of the individuals indicated on the Functional Performance Test Checklists. The Contractor shall submit in writing a list of all contractor and subcontractor representatives responsible for the functional performance testing phase of the project. This list of representatives shall be submitted 2

weeks prior to the commencement of functional performance testing of systems and equipment. All representatives shall remain on the commissioning team throughout functional performance testing. Substitutions will not be permitted. Functional performance test checklists shall be completed in the presence of all commissioning team personnel at the time of the functional performance test.

2. Upon failure of completion of a functional performance test checklist, the Contractor shall provide a written report to the CA listing the deficiencies causing the failure and remedies to correct all deficiencies. After the Contractor has corrected all deficiencies, the entire functional performance test checklist for the item of equipment shall be repeated. If possible, corrections can be accomplished during the functional performance testing of equipment in other non-related systems. In any case, no system will be accepted until all equipment items in the system have complete functional performance test checklists thereby demonstrating satisfactory performance.
3. Failure to complete 2 functional performance test checklists constitutes failure of Phase 2 of the HVAC Commissioning process. The Contractor shall provide a written report to the CA listing the deficiencies causing all failures and remedies to correct all deficiencies. After correction of all deficiencies, Phase 2 of the HVAC Commissioning process shall be repeated in its entirety. The Contractor shall give the CA 2 weeks notice before repeat functional performance testing is scheduled. Should the first or one subsequent functional performance test fail, the Owner reserves the right to obtain compensation from the Contractor for fees and expenses incurred in conjunction with having to perform more than two (2) functional performance tests.
4. Blank examples functional performance test checklists are in the Appendix 2 located at the end of this section of the specifications. A separate Functional Performance Checklist shall be provided for each system and piece of equipment to be Commissioned.

3.3 DEMONSTRATION TEST

A. After completion of system start-up, operating performance test and commissioning, but before Owner acceptance, the Contractor shall conduct a 72 hour dynamic mode demonstration of the systems provided under this Contract. The intent of the 72 hour dynamic test is to verify that the mechanical and electrical equipment will respond as designed to meet the changes that may occur under varying indoor/outdoor conditions including seasonal variations and occupancy loads.

B. A detailed procedure and sequence of events shall be developed by the Contractor and submitted to the Owner and CA for review and approval. Procedures and sequence of events should contain as a minimum the following activities:

1. Hours 1-4: Bring all systems on line for standard operations and parameters.
2. Hours 5-28: Operate all systems under normal parameters and verify proper operation.
3. Hours 29-52: Validation of systems operation through indoor/outdoor changes to include heating, cooling, ventilation, humidity control, domestic and control systems.
4. Hours 69-72: Return of systems to normal operation.

C. Systems and their associated equipment which are to be included in the dynamic test are all systems and components furnished under this Contract and as a minimum will include, but are not limited to the following:

1. Pressurization Air Handling Systems

2. Air Handling Systems
3. Chilled Water Systems
4. Domestic Water Systems
5. Fan Coil Systems
6. Pumping Systems
7. Exhaust Systems
8. Air Filtration Systems
9. Building Management and Control Systems

D. Contractor shall notify the Owner and CA in writing that the project is completed and ready for the demonstration test. Schedule for test will then be established and documented. Initiation of the 72 hours dynamic test will not occur until all systems are balanced, operational and incorporated into the building management and control system. Should the demonstration test fail for any reason, the problems shall be corrected and another demonstration test conducted. Should the first or one subsequent demonstration test fail, the Owner reserves the right to obtain compensation from the Contractor for fees and expenses incurred in conjunction with having to witness more than two (2) 72 hour demonstration tests.

E. The attendees of each 72 hour demonstration test shall include representative from the following organizations:

1. General Contractor
2. Mechanical Contractor
3. Electrical Contractor
4. Test and Balance Contractor
5. Building Management and Control System Contractor
6. Architect of Record
7. Mechanical Engineer
8. Electrical Engineer
9. Commissioning Agent

Minor problems are anticipated and the necessary personnel required to correct problems and adjust systems need to be available to insure continuation of the dynamic testing process. Is major problems are encountered, at the discretion of the Owner and CA, the testing will be terminated and rescheduled.

The Contractor shall notify any external organizations, which would include but not be limited to, Reedy Creek Energy Services, Reedy Creek Improvement District, AMCS and Fire Department which are not directly involved in the testing, but might be affected due to interface to insure that alarms do not occur.

F. During the demonstration test all systems shall operate in the “hands-off” automatic mode in accordance with the requirements of the Contract Documents. Changes in operating modes required to simulate load shifting, seasonal changeover, emergency modes, etc. will be accomplished by changing set points and equipment operating status at the BMS central control console as required to observe capacity control and monitoring. Provide a readout of space temperature at each thermostat building relative humidity, building pressurization, chilled water supply and return temperatures and chiller capacity.

END OF SECTION 230800

SECTION 23 0801 - COMMISSIONING AGENT REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Refer to section 23 08 00 for commissioning requirements and Division 1 for additional information.

1.2 DESCRIPTION OF THE WORK

A. This Section covers the Scope of Work for the Commissioning Agent (CA) who will be hired by the Owner.

B. The Commissioning Agent shall oversee the commissioning of the HVAC systems as described in Section 23 08 00. The CA shall prepare precommissioning and functional performance test checklists to be used by the Contractor. Prepare and publish a commissioning plan. Witness startup and operational tests of equipment and systems. Perform observations of the mechanical systems throughout construction and prepare the final commissioning document.

C. The CA shall have authority to direct and schedule test. The CA shall have no authority to direct changes to the systems.

1.3 COMMISSIONING PLAN

A. The CA shall prepare a plan listing the parties involved with their responsibility, scope, definitions, safety concerns, design criteria, attendance schedules, commissioning schedules, and commissioning manual requirements.

1.4 COMMISSIONING FORMS

A. Review 100% CD’s. Provide written summary of how each commissioned item of equipment, should operate include calculations verifying scheduled capacity.

B. The CA shall develop forms similar to that in Section 23 08 00 for the Contractors use during the commissioning process. The forms shall become part of the final commissioning manual. Forms shall be provided for each piece of commissioned equipment and system. Any deviations from the design shall be noted and proved by the Owner prior to acceptance. Each form shall be signed by the Contractor, CA and Owner prior to acceptance of a system or piece of equipment.

1.5 COMMISSIONED EQUIPMENT

A. All Air Handlers as scheduled.

B. All VAV, CAV and FP boxes as scheduled.

C. All pumps as scheduled.

D. All fan coils as scheduled.

E. All split systems as scheduled.

F. All fans as scheduled.

G. Chillers.

H. Cooling Tower.

I. Water Treatment.

J. Heat Exchanger.

1.6 COMMISSIONED SYSTEMS

A. All HVAC systems in Ballpark and Fieldhouse.

1.7 PROJECT OBSERVATIONS

A. The CA shall perform observations of the commissioned equipment and systems twice a month at a minimum and more as required to keep pace with construction. The CA shall note progress and any deviations of the construction documents shall be brought to attention of the Contractor and Owner for resolution. The CA will have no authority to direct changes or corrections to the system. Observation reports shall be published to the Owner, Architect and Contractor and shall be part of the final commissioning manual.

1.8 OPERATIONAL AND START-UP TESTS

A. The CA shall witness start-up tests and collect documentation of the tests. The CA shall notify the Architect and Contractor of any deviations from the contract documents. Any deviations shall be corrected or accepted by the Owner prior to acceptance.

B. After the Contractor has submitted in writing that the systems are completed, the CA shall schedule and direct operational tests of the systems. These tests shall be as described in Section 23 09 00 and 23 08 00. The results shall be documented and made part of the commissioning manual. Any deviations from the design shall be brought to the attention of the Architect and Contractor. Any deviations shall be corrected or accepted by the Owner prior to acceptance.

1.9 COMMISSIONING MANUAL

A. The CA shall prepare the final commissioning manual. The manual shall provide a complete history of the commissioning process and shall include:

1. Design and Energy Codes.
2. Commissioning Plan.
3. Completed Commissioning Forms.
4. Completed Observation Reports.

5. Completed Start-up Reports.
6. System Operational Tests.
7. Final sequence of operation to be achieved.
8. Summary of building operation as commissioned, noting deviations from design.
9. Design Criteria (extended from Design Documents by CA).
10. Written summary of normal startup and operating procedures for each commissioned item of equipment.

B. The manual shall be a three ring binder with tabs for each section. Provide 5 copies.

END OF SECTION 230801

SECTION 23 0900 - BUILDING AUTOMATION AND AUTOMATIC TEMPERATURE CONTROL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work described under this division is for all labor, materials, and equipment required for the construction of the Building Management System (BMS or BAS/Automatic Temperature Control (ATC) system.

B. The system shall be complete in all respects, tested and ready for operation.

C. All materials, equipment and apparatus shall be new and of first-class quality.

D. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters' Laboratories and comply with NEMA standards and the National Electric Code.

E. "Operator" is defined as the Owner's representative designated to operate the BMS/ATC system after Owner acceptance.

1.2 GENERAL INSTRUCTIONS

A. The BMS/ATC systems as specified herein shall be provided in their entirety by the BMS/ATC Contractor. The BMS/ATC Contractor shall base his Bid on the systems as specified.

B. The general provision of the contract (Division 1 and sections 23 05 01, 23 05 02, and 23 05 03) apply to work specified in this section.

C. The successful Contractor shall provide a BMS 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 office during the warranty period. The intent is to allow the Engineer lowest level Operator access during system installation, startup and demonstration.

1. This shall be made available to the engineer as soon as available. This Division is responsible for requesting IP address and coordinating software installation and access.

1.3 SCOPE

A. In general, the proposal shall be based on an electronic or electronic/pneumatic system. Valve and damper actuators may be electronic or pneumatically actuated – at BMS/ATC Contractor's option. Provide electronic sensors and transmitters with full DDC capabilities.

B. The engineering, installation, calibration, hardware, software programming and checkout necessary for complete and fully operational BMS/ATC systems, as specified hereafter, shall be provided under this division by the BMS/ATC Installer.

C. The BMS Contractor shall guarantee that the installed system is capable of maintaining the following comfort goals in conditioned areas served by the BMS.

1. Space Design Temperature +/- 1ºF.
2. Relative Humidity +/- 5%.
3. The BMS Contractor is not responsible for improper installation by other Divisions; however the BMS Contractor is responsible for informing the Construction Manager and Engineer of any requirements of this specification or any installation problem which prevents these goals from being maintained.

1.4 ITEMS REQUIRED TO BE COORDINATED WITH OTHER DIVISIONS

A. Contractor shall be responsible for coordinating the following:

1. Power requirements (voltage, amps, location) for all BMS equipment requiring power. See Section 23 05 01.

B. Installation and connection of all power wiring. Power wiring shall be defined as follows:

1. Wiring of power feeds through all disconnect starters and variable speed controllers to electric motors.
2. 120 VAC Emergency and 120V Normal power feeds to all BAS temperature control panels and equipment.
3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by the BAS/ATC Contractor.
4. See Division 23 05 01 for responsibilities.

C. Note that 120V to 24V surge protected transformers for low voltage wiring by this Division shall be furnished, set in place and wired (from designated circuit in electrical panel) by this Division, and all low voltage control wiring shall be installed under this Division.

1.5 WORK BY OTHERS

A. The following work shall be provided under separate divisions of the specifications:

1. Installation of all line size and non-line size automatic valves and separable wells. However, these devices shall be furnished under this division.
2. Provision of all necessary piping connections, taps and direct-contact wells required for flow, pressure or temperature devices specified under other divisions.
3. Provision of manual balancing dampers as specified under other divisions of Divisions 21 through 23.
4. Installation of all automatic control dampers shall be under Division 3 31 13. However, all control dampers shall be furnished under this division.

1.6 AGENCY LISTINGS

A. UL 916 PAZX Energy Management Systems.

B. FCC-Part 15 Subparagraph J. Class A. Emissions requirements.

C. UL-864/UUKL Smoke Removal.

1.7 RELATED SECTIONS

A. 23 05 01 - Mechanical and Electrical Coordination.

B. 23 05 02 - Basic Mechanical Requirements.

C. 23 05 03 - Basic Mechanical Materials and Methods.

1.8 BMS/ATC CONTRACTOR

A. The BMS/ATC Contractor shall have a local office within a 50 mile radius of the job site, staffed with factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency maintenance service on all system components. The BMS/ATC Contractor shall have a ten year experience record in the design and installation of computerized building systems similar in scope and performance to that specified herein, and shall be prepared to provide evidence of this history prior to Contract Award should the Owner request it.

B. The BMS/ATC Contractor shall be prepared to make a personal presentation of his systems to the Owner or his designated representatives prior to award of Contract should the Owner request it.

C. The engineering, installation, calibration, hardware, software programming and checkout necessary for complete and fully operational BMS/ACT systems, shall be provided under this division by the BMS/ATC Installer.

D. Control components shall be mounted and wired by the BAS/ACT Contractor except as noted. Controllers may be mounted on terminal units at the factory.

1.9 SUBMITTALS AFTER CONTRACT AWARD

A. The following data/information shall be submitted for approval:

1. Complete sequence of operation.
2. Control system Cad generated drawings including all pertinent data to provide a functional operating system.
3. Valve, and damper schedules showing size, configuration, capacity and location of all equipment.
4. Data sheets for all hardware and software control components.
5. A description of the installation materials including conduit, wire, flex, etc.
6. Building Management System panel locations.

B. The Controls Contractor shall provide submitted drawings for the entire control system for review and approval before work shall begin. Included in the submittal drawings shall be a diagram depicting the system architecture complete with a communications riser. Drawings shall include point-to-point wiring diagrams and must show all temperature controls, start-stop arrangement for each piece of equipment, equipment interlocks, wiring terminal numbers and any special connection information required for properly controlling the mechanical equipment.

The submittal shall include a bill of material reference list as well as equipment sequences of operation.

C. The submittals shall include a specification compliance analysis for review and approval before work shall begin. The compliance document shall address each paragraph of this specification by indicating COMPLY, EXCEED, or EXCEPTION. Do not indicate COMPLY unless the proposed system exactly meets the paragraph requirement. If EXCEED or EXCEPTION is indicated, then provide a clear and concise explanation of the variance from the specifications and the net effect this would have on the specified system performance.

D. Wiring diagrams shall include internal wiring of all electrical control devices.

E. Submit completed computer graphics for all the equipment and building floor plans minimum floors prior to scheduled completion of the project for approval.

PART 2 - PRODUCTS

2.1 GENERAL

A. The Building Management System (BMS) shall provide an easy to use interface for monitoring and managing the building. The Building Management System shall provide the necessary Hardware, Software, and Network Communication abilities to provide Scheduling, Monitoring, Trending, Historical Storage, and Alarm Functions for the HVAC equipment and systems as described in this specification. Control capabilities shall include: Time of Day scheduling, Direct Digital Control, Custom Control, Boolean Logic, Optimum Start/Stop, Duty Cycling, Electrical Demand Control, Temperature Control, After Hours Override, Reports and Logs, Trend Prints, Remote Communications, Alarm Logging, Run Time and Maintenance, and Expanded Informational Messages.

B. The BMS shall utilize either Bacnet or Lonworks open protocol.

C. The BMS shall be fully accessible via secure internet connection. All required software and/or access to be provided to Engineer for use in troubleshooting.

D. The Building Management system shall be designed to allow full Operator operation with a minimum of training. It shall have an on-screen “Help” Operator tutorial.

E. Specified application programs shall be engineered, programmed and pre-tested prior to site installation. This shall be verified by standard format programming worksheets or flow diagrams included with the submittals.

2.2 BUILDING MANAGEMENT SYSTEM

A. Each panel memory shall be protected for a minimum of 48 hours in the event of power failure. Internal clock shall continue to run during a power failure so that the system makes the appropriate adjustment to all connected points when power is restored.

B. When specified or indicated on the point list or where required by the sequence of operation, outputs shall have three position manual override switch (On/Off/Auto), a status light, and shall

be selectable for either normally open or closed operation.

2.3 MANUFACTURERS

A. Acceptable Manufacturers Are:

1. Johnson Controls as installed by local factory office.
2. Siemens as installed by local factory office.
3. Alerton as installed by local factory authorized office.
4. KMC as installed by local factory authorized office.
5. Tridium as installed by local factory authorized office.
6. Trane as installed by local factory office.

Any other manufacturer shall be considered a substitution and may submit for approval after the bid.

2.4 OPERATOR INTERFACE

A. Local Interface. Furnish PC based workstations. Each of these graphics based workstations shall be able to access all information in the system. These workstations shall reside on the same high speed LAN as the building controllers. Each workstation shall be able to be custom configured based on the needs of the operator.

B. Hardware. Each operator workstation and custom programming workstation shall consist of the following:

1. Personal Computer. The CPU shall be a minimum of an Intel Core-i5 and operate at a minimum of 2.8 GHz. A minimum of 4 GB of RAM with expansion to 8 GB, DVD drive, Windows Professional, Enterprise or Ultimate editions 64-bit Operating System, a 150 GB hard disk with a minimum of 7,200 RPM shall be provided. A three button mouse and keyboard will also be provided. Furnish all required USB and LAN communication ports or wireless capability for proper system operation. The PC shall have a minimum of a 27" flat panel monitor.
2. Provide a UPS battery backup comparable to an APC 550 VA desktop backup.
3. Printers: Each work station shall have one (1) printer connected from the network or dedicated office inkjet printer with USB cable.
4. Network Card: Provide Ethernet 10/100/1000 MBPS PCI card.

C. Workstation Software

1. Multiple Users: The system shall accommodate simultaneous multiple user operation. Access to the system data should be limited only by operator password. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the system and have access to all valid data.
2. Operating System: Furnish a concurrent multi-tasking operating system. The operating system shall also support the use of other common software applications that operate under Microsoft Windows Professional such as Microsoft Office.
3. System Graphics: The Operator Workstation software shall be graphically oriented. The system shall allow display of up to multiple graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between

graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on line. An operator with the proper password level shall be able to add, delete, or change dynamic points on a graphic. Dynamic points shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the point.

a. Standard Graphics. Provide graphics for each major piece of equipment in the building. This includes but not limited to, each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These standard graphics shall show all points as specified in the points list.
b. Custom Graphics. The system shall have custom graphics provided for all air handling systems and hydronic systems. Graphics shall also include actual floor plans showing equipment, and sensors. Custom graphic files shall be created with the use of a PC Paint package furnished with the system. The PC Paint package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The PC Paint package shall also provide the capability of capturing or converting graphics from other programs such as Designer, or AutoCad.
c. Graphics Library. Furnish a complete library of common HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library shall also include symbols for other equipment including fans, pumps, valves, piping, and ductwork. The library shall be furnished in a file format compatible with the PC Paint Program.
d. Photo Quality Input. The system shall be able to accommodate high resolution digitized photographs. These shall be scanned in from photographs or 35 MM slides. The owner shall be able to edit the photo quality graphics using the furnished PC Paint Program.

4. Workstation Applications. The workstation shall serve as the primary area of the system for operator interface and off-line storage of system information. The workstation shall also serve as the bridge to other building systems. Provide the following applications at the workstation.
   a. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to save the database from any system panel. The operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
   b. System Configuration. The workstation software shall provide a simple to use graphical method of configuring the system. As elements are located on the site they shall be displayed on a graphical representation of the system. This shall be flexible to allow for future system changes or additions.
   c. On Line Help. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
   d. Security. Each operator shall be required to log on to the system with a user name and a password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application, editor, and object (i.e. Operator One can view and change all airside data but only view chiller plant data, operator two can only acknowledge alarms

and not view or change system data etc.) Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto logoff time shall be set per operator password. All system security data shall be stored in an encrypted format in the building management panels.

e. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, LAN connections, building management panels and controllers. The failure of any device shall be annunciated to the operator.

f. Trend Logs. Each object in the system shall automatically be trend logged. This trend shall be stored for a minimum of 24 hours. The operator shall be able to view this trend on demand.

g. Event Log. The operator shall be able to view all systems alarms and change of states. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms. All that have not been cleared by the operator shall be archived to the hard disk on the workstation.

h. Point Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. These statuses shall be available by menu on graphics or through custom programs.

i. Clock Synchronization. The real time clocks in all building control panels and workstations shall be synchronized on command of an operator. The system shall also be able to automatically sequence all system clocks, daily from any operator designated device in the system. The system shall automatically adjust for daylight savings and standard time if applicable.

5. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, states and reactions for each object in the system.

   a. Binary Alarms. Each binary object shall be set to alarm based on the operator specified state. Provide the capability to automatically and manually disable alarming.

   b. Analog Alarms. Each analog object shall have both high and low alarm limits a well as high and low “early warning” limits. Provide separate sets of limits for both occupied and unoccupied (on/off) conditions. Alarming must be able to be automatically or manually disabled.

   c. Alarm Reactions. The operator shall be able to determine what action if any is to be taken, by object, during an alarm. Actions shall include logging, printing, starting programs, displaying messages, providing audible annunciation or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day. The system shall provide multiple levels of alarm priority.

6. Workstation Applications Editors. Each PC workstation shall support editing of all system applications. Provide graphically based editors for each application at the PC workstation. The applications shall be downloaded and executed at one or more of the building management panels.

   a. Application Specific Controller. Provide a full page editor for each application specific controller. This shall allow the operator to view and change the configuration, name, control parameters and set points for each device.

   b. Scheduling.

      1) A complete graphically based editor for the scheduling application shall be provided at each workstation. Provide an easy to use method of selecting the desired schedule and month.

      2) This shall consist of graphically represented daily schedules and holidays.

3) Provide the capability for seasonal schedules that will be automatically executed during user defined periods. This shall enable the operator to have a group of equipment in discrete "Summer" and "Winter" schedules. Each seasonal schedule shall only be active during the operator specified time periods. The schedule shall be available for viewing and editing even when not active. The operator viewing a schedule shall be able to see graphically whether the schedule is active or inactive for up to a year in advance.
4) An operator with proper password level shall be able to modify the schedule. Schedules shall be able to be easily copied between objects and/or dates.

7. Custom Programming Language. Provide the capability to perform custom applications. The custom programming editor shall be accessible from all workstations. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded. Systems that require the operator interface be shut down to edit and compile programs shall include and additional Custom Programming Workstation. This workstation shall be identical to the operator's workstation in section 2.04.B.

   The Program editor shall allow for creation, editing, troubleshooting, and simulation of custom programs. The editor shall check for proper programming context, use, spelling, and format. The custom programming editor shall also compile the program and be able to upload and download to the building management panel. All custom routines shall be executed at the building management panel.
8. Alarm Annunciation.
   a. Upon the incidence of an alarm, an alarm window shall be displayed showing the point in alarm, the time and date of the alarm and a user-selected predefined alarm message (and optionally printed to a user defined printer, printers and/or VT-100 or dumb terminal devices). Alarms shall be displayed regardless of the application in use including any non-ddc system DOS or Windows applications. The program shall display the current unacknowledged and acknowledged alarms. The user shall be able to selectively enable or disable a reminder in the event there are unacknowledged alarms. This reminder shall be both visual and audible. The user shall be able to record their own reminder messages and select the frequency at which they will play.
   b. Acknowledgement of alarms shall be from the alarm "pop-up" and/or from a separate alarm summary. Acknowledgment shall be by a specific event, date range, class, or specific alarm definition and condition. Upon acknowledging the alarm, the name of the operator acknowledging the alarm and the time and date will be associated with the acknowledgement, this data will be stored to the alarm history file and printed to the chosen printers or terminal devices.
   c. The system shall allow automatic or manual display of associated dynamic graphic screens and trend charts shall be provided for each alarm.
   d. Upon exiting the alarm handling mode the user shall be placed back to the application in use at the time of alarm/exception occurrence.
   e. A current alarm screen shall be provided which will dynamically display only alarms that are currently in alarm. As alarms are return-to-normal from their respective alarm states the current alarm screen shall be dynamically updated to reflect the change.
9. Trend Management

a. The program shall automatically perform time based periodic collection of real time point data and subsequently store it to the systems hard disk. There shall be local and remote modes of operation. Local collection shall allow the program to directly query the controllers for individual point samples. Remote collection shall mean the controllers collect and store trend data on individual points and then release the entire trend table(s) upon a request from the computer work station.
b. Storage and manipulation of sample points shall only be limited by disk space. Sampling rates shall be user selectable from instantaneous (once a second or less) to once a week. Collection of data shall be user selectable to start and stop on specific times and dates.
c. Charting of the trend data shall be an integral part of the trend management program. Third party graphing packages such as Excel or Lotus 123 shall not be required to implement this program. Multiple points shall be chartable. Multiple X/Y charts may be run simultaneously displaying either real time data (instantaneous) or historical. Y scaling shall be either automatic or user selectable for any chart displayed, each chart may have different scaling. X scales shall be user selectable allowing for display of data over the wide range of times and dates. Multiple years of data shall be allowed. The chart display shall be capable of displaying a window of time as short as 15 seconds. Average, high and low values shall be displayed for selected point.

10. Reporting
    a. The report section shall be the gateway to the database for all data collected and shall provide an easy means of reporting and information management.
    b. The report generator shall be an integral part of the system. Offline third party packages (such as Excel) for report manipulation shall not be required to implement this program.
    c. Reports on historical trend data shall allow for daily, weekly, monthly and yearly reporting. These reports shall be completely flexible on the data items to be reported on. The user shall be able to select from a list of predefined reports or selected data items on-the-fly. The selection of data item shall not be restricted by panel source. Reports shall have multiple columns and be infinite in length. Reports must be capable of reporting on data that has been collected at varying time intervals. Report generator shall allow an operator to easily and quickly define the contents of a report as well as define a print time and date if so desired. Information contained in the reports shall be derived from alarm history, system database, trend data and timed overrides.
    d. The operator shall be able to compile reports by user, department, time and data period, point or points.
11. Multi-tasking
    a. The system shall be capable of true multi-tasking capabilities. The user shall be able to use other non-related programs in the system while still running all ddc system application with no interruptions. This shall include the use of real time data in other applications. This feature shall allow spread sheet programs to gather data from the system dynamically while running a dynamically updated graphic screen. The system shall have the ability to allow the passing of data freely to MS Windows application, which incorporate the use of Dynamic Data Exchange.

2.5 SYSTEM PERFORMANCE

A. The system shall consist of Operator Workstation, Building Management Panels, and Application Specific Controllers. All elements of the system shall be designed for standalone operation. Control shall always occur at the lowest level of the system. Communication between the building management panels and workstations shall be over a high speed communications buss. All nodes on this LAN shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the building management panels to update point information and alarm information.

2.6 SYSTEM APPLICATION CONTROLLER SOFTWARE

A. System Security: User access shall be secured using individual security passwords and user names.

B. Passwords shall restrict the user to only the object, applications and system functions as assigned by the system manager.

2.7 SYSTEM SOFTWARE

A. Furnish the following applications for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator workstation.

1. Scheduling: Provide the capability to schedule each object or group of objects in the system. Each scheduler shall consist of the following:
    a. Weekly Schedule: Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. Each scheduler may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each number.
    b. Exception Schedules: Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to one year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
    c. Holiday Schedules: Provide the capability for the operator to define up to 30 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
2. Optimal Start/Stop: The scheduling application outlined above shall support an optimal start/stop algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. Provide an early start limit in minutes to prevent the system from starting too early.
3. System Coordination: Provide a standard application for the proper coordination of equipment.
4. Alarm Reporting.
5. Trending.
6. Diagnostics.
7. Power Fail Recovery.
8. Reports and Logs.

9. Chiller Sequencing.

2.8 NETWORK CONTROLLERS

A. General. Provide an adequate number of Building Management Panels to provide the performance specified above. Each of these panels shall meet the following requirements.

1. The Building Automation System shall be composed of one or more independent stand-alone, microprocessor based Network Controllers to manage the global strategies describes in Application software section.
2. The Master Controller shall have substantial memory to support its operating system, database, and programming requirements.
3. The multi-tasking operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
4. Data shall automatically be shared between Master Controllers when they are networked together.
5. The database and custom programming routines of remote Network Controllers shall be editable from a single operator station.
6. The Master Controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
    a. Assume a predetermined failure mode.
    b. Emit an alarm.
    c. Display card failure identification.

B. Each master controller shall reside on an Echelon LonWorks/LonTalk protocol network with data transmission speeds of at least 1.25 MBPS.

C. Serviceability. The Network Controller should be designed in a modular fashion so that the enclosure may be roughed in prior to the installation of the electronics. Provide diagnostic LEDs for power, communications, and alarms. The controller shall have provisions for expansion and future controller architecture. All wiring connections shall be made to field serviceable terminal strips or to a termination card connected by a ribbon cable.

D. Memory. The Network Controller shall maintain all BIOS and programming information in EEPROM. The system BIOS shall be easily upgradable for the PC workstation without the need for going out to the panel. System manufacturer shall provide current version software and firmware at the end of the warranty period.

2.9 APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient EEPROM memory to handle its operating system, database and programming requirements.

The controllers shall be clearly labeled as to controller type, where it is to be installed, and software address (if applicable). The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

B. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.

C. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at –40°F to 155°F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

D. Box Controllers

1. The VAV terminal units shall be individually controlled by a dedicated DDC VAV controller. The DDC VAV controller, damper motor, transducer and transformer (if required) shall be supplied by the BAS contractor.
   a. To assure proper operation and control, the BAS contractor as part of this bid, shall recalibrate the transducers six (6) months after acceptance of the BMS system to correct any deviations as a result of transducer drift.
   b. Submit a copy of the recalibration report to the Engineer, Mechanical Contractor, Test, Adjust and Balance Contractor and Owner.
2. The BMS shall perform the following VAV Terminal unit control strategies and provide the points as listed on the DDC/VAV point list and specified monitoring and diagnostics.
   a. Grouping: The BAS shall be able to group VAV boxes via keyboard commands. These groups shall make it possible for the operator to send a common command to all boxes in a group to operate in the same mode. A sample of this group report must be provided in the submittal package for approval by Engineer and Owner. BAS shall also compile on a group basis, the following:
      1) Minimum group temperature.
      2) Maximum group temperature.
      3) Average group temperature.
      4) Current airflow through boxes in group (total).
      5) Total ventilation airflow in group (total).
   b. Setpoint Control: The BMS shall edit the zone space temperature setpoint of each VAV box. The zone temperature setpoint shall be operator adjustable. Individual zone setpoint and control logic shall reside at the zone level, and not be dependent upon the BMS for control. In the event of communication loss, the box will continue to control to current setpoints.
   c. Manual/Automatic Setpoint Control: Where indicated in the contract documents, provide a combination zone temperature sensor/thermostat (S/T) with master control via the Operator's Work Station. In automatic mode, the S/T shall operate only as a room sensor. In Manual mode, the space occupant shall have the capability to raise or lower space setpoint.
   d. Override Button: Where indicated on the contract documents, the VAV box shall be capable of being placed in the "occupied" mode. Operation of the over-ride shall energize the associated air handler.
   e. Override Cancel Button: The VAV box shall be capable of being placed back into the "occupied" mode by the zone occupant.
      1) The following areas shall have manual temperature re-set capability and unoccupied over-ride button:
         a) All office areas.

b) All other areas shall have temperature sensing capability only.

f. Cooling Valve Control: The BMS shall control the cooling air valve to a fully open, fully close, maximum CFM, or minimum CFM position based on operator commands. The operator shall also have the capability to adjust the maximum and minimum airflow limits of the air valve through the BMS.

g. Operating Mode: The BMS shall place the box in either the occupied or unoccupied mode based on an operator adjustable time schedule. Separate heating and cooling setpoints shall be enterable for each mode through the BMS. Other modes available for special applications shall include full open, full closed, maximum flow, heating flow, minimum flow, [and "Game Day/VAV" occupied minimum flow].

h. Occupied status shall be further divided into Game Day/Office/or Player Occupied schedule as appropriate. Certain public or player occupied areas shall have a higher "minimum occupied" setting for Game Day or Player Occupied time periods.

i. Control Offset: The BMS shall be capable of offsetting the cooling or heating setpoints of one or more groups of boxes by an operator adjustable amount. This capacity will allow for automatic zone setpoint changes based on system requirements, such as demand limiting.

j. Automatic Recalibration: The system shall automatically recalibrate its air flow sensing and air valve position measurement system at system startup and on a schedule basis.

k. Portable interface terminal: The VAV box shall have a communications port on the space sensor for use with a hand held portable operator's terminal. This portable terminal shall give the operator the capability to interrogate and edit DDC/VAV box parameters. Portable interface terminal shall also have the capability to interrogate and edit DDC/VAV box parameters from a central controller.

l. Terminal Unit Status Reports: For each terminal unit, the BMS shall provide an operating status summary of all unit sensed values (zone temperature, CFM, etc.), setpoint and modes.

m. Terminal Unit Group Report: For each group of VAV terminal units, the BMS shall report the group mode, heating and cooling airflow, average zone temperature, minimum zone temperature, and maximum zone temperature. The report shall also display for each terminal unit in the group, the present temperature control setpoints and the current zone temperature.

3. Terminal Box Diagnostics:

a. If zone temperature sensor input fails above its high range, unit shall control at its maximum CFM setpoint. If sensor input fails below its low range, units shall control to its minimum CFM setpoint.

b. In both cases, all heat outputs shall be disabled. A diagnostic message shall be displayed upon operator inquiry.

c. If flow measuring system fails, unit shall automatically convert to a pressure dependent, damper position based algorithm. Diagnostic message shall be displayed upon operator inquiry.

d. If zone temperature setpoint potentiometer on zone sensor fails, unit shall automatically control to programmed occupied setpoints. Diagnostic message shall be displayed upon operator inquiry.

e. If communications are not lost, controller shall continue to operate in current mode of operation. All setpoints shall be retained in nonvolatile memory. If

communications are not restored within 15 minutes, unit shall automatically initiate a reset-recalibrate.

2.10 CUSTOM APPLICATION CONTROLLERS

A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient EEPROM memory to support its operation system, database, and programming requirements. Custom application controllers shall meet the requirements of 2.06 Master Control Panels except they shall reside on a communications network operating at a minimum of 38,400 KBPS.

B. All programming required for operation shall be memory resident and shall be retained in permanent memory.

C. The Custom Application Controller shall be configured such that the Portable Operators Terminal can be plugged directly into it or within sight for programming, editing, and other operator functions. Custom application controllers shall also be programmable from the operator workstation.

D. Controller hardware shall be suitable for the anticipated ambient conditions.

E. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures and shall be rated for operation at –40°F to 155°F.

F. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

2.11 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through Master Control Panel, Custom Application, or Application Specific Controllers. Any critical points requiring immediate reaction shall be tied directly in to the controller hosting the control software algorithm for the critical function.

B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a sufficient wetting current to be compatible with commonly available control devices.

All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.

C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices. Where specified in the sequence of operations or indicated on the points list, binary outputs shall have 3-position (on/off/auto) override switches, status lights, and shall be selectable for either normally open or normally closed position.

E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 0 to 20 VDC or a 4 to 20 milliampere signal as required to provide proper control of the output device. Systems that utilize a pulse width modulating output (PWM) shall include a position feedback AI for each output.

F. System architecture shall allow for point expansion in one of the following ways:

1. The addition of input/output cards to an existing System Application Controller.
2. An additional panel and/or controller may be used to expand point capacity.
3. Ten (10) percent expansion capacity for all point typed in all DDC panels.

2.12 IDENTIFICATION

A. Engraved Labels

1. Material: Melamine plastic laminate.
2. Thickness: 1/16".
3. Color
   a. Surface: White.
   b. Core: Black (letter color).
4. Fastenings: Any of the following:
   a. Screws.
   b. Rivets.
   c. Permanent adhesive.
5. Lettering: Coordinate with shop drawings.

2.13 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be provided and wired in accordance with Section 23 05 01.

2.14 PIPING

A. Exposed Air Piping: Hard copper tubing or flame-resistant plenum rated polyethylene tubing in metal conduit or trough.

B. Concealed Air Piping:

1. Soft copper tubing, or flame-resistant plenum rated polyethylene tubing, properly supported.
2. Do not use polyethylene tubing near sources of heat.

2.15 BMS/ATC CONTROL WIRING

A. General: 18 AWG Twisted pair cable shield wire shall be provided if required by system manufacturer.

B. Provide for all input and all analog output wiring.

C. Tinned copper conductors.

D. Do not run input/output wires together in the same conduit or wire bundle with 120V power wiring.

E. Pneumatic or sensor tubing shall not be installed in conduit with any wiring conductors.

F. All control wiring shall be run in rigid conduit complying with Division 26 requirements.

2.16 AUXILIARY CONTROL DEVICES

A. Dampers:

1. The Building Automation System supplier shall provide all automatic control dampers not specified to be supplied integral to the HVAC equipment.
2. Dampers shall be low leakage or high velocity low leakage air foil as specified in the sequence of operation or in the equipment specifications and schedules. All proportional dampers shall be opposed blade type, except mixing dampers shall be parallel type. Two position dampers may be opposed or parallel blade type.
3. Damper frames and blades shall be galvanized steel and a minimum of 16 gauge. Blade width shall not exceed 8 inches. Dampers and seals shall be suitable for temperature ranges of –50°F to 250ºF.
4. Blades: 14-gauge, or 16-gauge air foil shaped, double, galvanized steel or extruded aluminum.
5. Bearings: Nylon or oil impregnated.
6. Axles: Welded, hexagonal or pin lock, or with other approved method to prevent blade rotating on axle.
7. Hardware: Zinc plated steel or aluminum.
8. Standard Low Leakage Dampers:
    a. Standard low leakage dampers shall be provided to conserve energy. Dampers shall be equipped with neoprene edge seals and compressible metal jamb seals. Leakage shall not exceed 10 CFM/Sq. Ft. at 4” W.G. differential.
    b. Standard Low Leakage dampers shall be Ruskin, Model CD36 or equivalent.
9. High Velocity Low Leakage Dampers:
    a. Where specifically called out as “LOW LEAKAGE”, provide the following:
        1) Field replaceable edge and end seals with be installed along the top, bottom, and side of the frame and each blade. Seals and bearings shall be suitable for temperature ranges from –40ºF to 200ºF. Leakage shall not exceed 6 CFM/Sq. Ft. at 4” W.G. differential.
        2) High Velocity Low Leakage dampers shall be Ruskin, Model CD60 or equivalent.
10. Provide low leakage dampers in the following locations:
    a. Outside air dampers.
    b. Motorized backdraft dampers.
    c. Motorized intake dampers.

2.17 CONTROL VALVES

A. Provide control valves of the type, body material and pressure class as determined by manufacturer, based on operating requirements and maximum pressure and temperature in the piping system.

B. Equip control valves with actuators of proper close-off rating.

C. Modulating control valves shall have equal percentage or linear flow characteristics.

D. Valve bodies shall be 2-way normally open or closed, or 3-way mixing as specified. Valve bodies 2" and smaller shall be bronze, screwed type and 2½" and larger shall be iron, flanged and rated at 240°F 125 psig except where otherwise noted.

E. Valves shall have stainless steel stems and allow for servicing including packing, stem, and disk replacement, or offer a 5 year warranty on parts and labor.

F. Size valves for 50% coil pressure drop (minimum 3', maximum 12' pressure drop).

G. Two-position, two-way control valves shall have quick opening characteristics.

H. Three-way valves shown in mixing application shall have a single, double faced disk.

I. Three-way valves shown in diverting application shall have two separate disks on a common shaft.

2.18 VALVE ACTUATORS: (ELECTRIC)

A. Valve actuators shall be electronic low voltage (24VAC), and properly selected for the valve body and service. Belimo or equivalent.

B. Actuators shall be fully proportioning (if modulating) and be spring return for normally open or normally closed operation as called out in the sequence of operations.

C. Provide a handwheel or manual positioner mounted adjacent to valve to allow manual positioning of valve in the absence of power.

D. Tri-state floating control non-spring return actuators are acceptable for terminal reheat applications for sizes less than one inch.

E. Actuators that rely on heating a medium are not acceptable.

2.19 BUTTERFLY VALVES

Butterfly valves used for automatic control shall be lug type rated for 125 psi non-shock water service to 180°F.

A. Valve body shall be ductile iron with B-Nitrite (BUNA N) or EPDM molded seat and seals.

B. Disc material shall be cast bronze of aluminum-bronze with ASTM A-492 Type 416SS stainless steel stem and fittings.

C. Valves shall be tight close off suitable for end of the line service.

D. Butterfly valves used for two position control shall be line size. Valves used for modulating control shall be sized for a minimum 5 psig differential pressure at full flow.

E. Three way valve mixing or diverting configurations shall have factory provided linkage kits specifically manufactured for the piping arrangement and actuator used. Keystone or approved equivalent.

2.20 TEMPERATURE SENSORS

A. Temperature sensors shall be Resistance Temperature Detector (RTD) or Thermistor as dictated by the requirements of this specification.

B. Duct sensors shall be rigid or averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 5 feet in length.

C. Immersion sensors shall be provided with a separable stainless steel or brass well to match pipe material.

D. Space sensors shall be equipped with setpoint adjustment and/or override switch as specified on the plans or in the sequence of operations. Space sensor shall have a portable service tool jack.

E. Accuracies shall be +/-1°F for standard applications. Where high accuracy is required, accuracies shall be +/- .2°F.

F. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacturer's recommendation and looped and fastened at a minimum of every 36 inches.

G. Sunshields shall be provided for outside air sensors.

2.21 HUMIDITY SENSORS

A. Humidity sensors shall be capacitance or bulk polymer resistance type.

B. Duct and room sensors shall have a sensing range of 20 to 80% with accuracy of +/-3% R.H. Duct sensors shall be provided with a sampling chamber.

C. Outdoor air humidity sensors shall have a sensing range of 20 to 95% RH. They shall be suitable for ambient conditions of –40°F to 170°F.

2.22 DIFFERENTIAL PRESSURE AND CURRENT SWITCHES

A. Differential Pressure Switches shall be furnished as indicated for status purposes in air and water applications. Provide single pole double throw switch with fully adjustable differential pressure settings.

B. Sensing range shall be suitable for the application with accuracy of +/-2% of range and repeatability of +/-.5 % of range. Sensor shall be capable of withstanding up to 150% of rate pressure without damage.

C. Current switches shall be provided for status indications on variable air flow fans and variable pump speed applications. These switches shall be capable of installation and replacement without removing power wiring.

2.23 CARBON DIOXIDE (CO2) DETECTION SENSOR

A. Provide carbon dioxide gas detection sensors as indicated on drawings. Carbon dioxide detection sensors shall meet, at minimum, the following requirements:

1. Negligible temperature and humidity effect on accuracy.
2. 4-20 mA transducer interface with the BMS proportional to 0 to 2,000 ppm of carbon dioxide concentration.
3. 24 VAC or VDC @ 400 mA max voltage.
4. No maintenance or period sensor replacement needed.
5. Accuracy- 5% of reading or 100 ppm, whichever is greater.
6. Operating temperature of 32° F to 122° F.
7. Aspirating box.
8. Outside air sensor shall be environmentally protected.

2.24 CARBON MONOXIDE (CO) DETECTION SENSOR

A. Provide carbon monoxide gas detection sensors as indicated on drawings. Carbon monoxide detection sensors shall meet, at minimum, the following requirements:

1. Negligible temperature and humidity effect on accuracy.
2. 4-20 mA transducer interface with the BMS proportional to 0 to 250 ppm of carbon monoxide concentration.
3. 24 VAC or VDC @ 400 mA max voltage.
4. No maintenance or period sensor replacement needed.
5. Accuracy 2% of reading or 5 ppm, whichever is greater.
6. Operating temperature of 32° F to 122° F.
7. Aspirating box.
8. Outside air sensor shall be environmentally protected.
9. Activate purge fan mode at 25 ppm. Activate full alarm mode at 200 ppm.

2.25 NITROGEN DIOXIDE (NO2) DETECTION SENSOR

A. Provide carbon dioxide gas detection sensors as indicated on drawings. Nitrogen dioxide detection sensors shall meet, at minimum, the following requirements:

1. Negligible temperature and humidity effect on accuracy.
2. 4-20 mA transducer interface with the BMS proportional to 0 to 10 ppm of nitrogen dioxide concentration.
3. 24 VAC or VDC @ 400 mA max voltage.
4. No maintenance or period sensor replacement needed.
5. Accuracy- 2% of reading or 2 ppm, whichever is greater.
6. Operating temperature of 32° F to 122° F.
7. Aspirating box.
8. Outside air sensor shall be environmentally protected.

9. Activate purge fan mode at 0.72 ppm. Activate full alarm mode at 2 ppm.

2.26 STATIC PRESSURE SENSORS

A. Static pressure sensors shall be differential pressure type. The sensor range shall be closely matched to the system static pressure, - .5 to .5 inches, -1 to 1 inches, 0 to 2.5 inches.

B. Sensor accuracy shall be plus or minus 5% of the sensing range, and repeatability of 2% of sensor range.

PART 3 - EXECUTION

3.1 FUNCTION

A. Provide all components necessary to achieve the Sequences of Operation listed in Part IV and any additional industry standard functions normally required of a first class BMS/ATC installation.

B. This division shall provide a project manager who shall, as a part of his duties, be responsible for the following activities:

1. Coordination between this Contractor and all other trades, Owner, local authorities and the design team.
2. Scheduling of manpower, material delivery, equipment installation and checkout.
3. Maintenance of construction records such as project scheduling, manpower planning, and as-built drawings for project coordination and as-built drawings.

3.2 INSTALLATION METHODS

A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division-26 sections of these specifications.

B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devises.

C. Control Wiring:

1. Number-code or color-code conductors appropriately for future identification and servicing of control system.
2. All line voltage power wiring required because of substitution of low voltage power wiring equipment specified in this division, shall be provided by this division.
3. Comply with the applicable requirements of Division 26 for the installation of electrical wiring incidental to the temperature control system.
4. Comply with the applicable requirements of National Electrical Code and Standard Building Code for the installation of electrical wiring incidental to the temperature control system.
5. Control wiring shall be run in conduit (conduit to meet requirements of Division 26).

6. Conduit shall be run parallel to building lines properly supported and sized at a maximum of 40% fill. In no cases shall field installed conduit smaller than ½" trade size be allowed.
7. Where conductors are not in conduit (as allowed through an owner accepted substation request) cable rated for use in return air plenums shall be used in all locations.
8. BMS/ATC division shall provide all control transformers and all control wiring (including low voltage actuator power wiring). This division shall also provide power wiring from the control circuits to the transformer locations and all other temperature control devices requiring power wiring. Division 26 shall furnish appropriate control circuits (both normal and emergency) in suitable panelboards located throughout the project.
9. BMS/ATC division shall provide UL listed surge protectors for all control circuits upstream of control transformers.

D. Piping System:

1. Provide a complete air piping system for pneumatic actuator controls (if selected by Contractor).
2. Conceal piping except in:
   a. Mechanical rooms.
   b. Areas where other piping is exposed.
3. Secure exposed copper tubing at regular intervals and run parallel with the lines of the building.
4. Install only tool-make pipe bends.
5. Where exposed in mechanical rooms and occupied spaces, support non-metallic tubing in:
   a. Adequately-supported, rigid, metallic raceways.
   b. EMT pipe
   c. Duct
6. Support non-metallic tubing properly where installed in concealed locations, including:
   a. Pipe chases
   b. Ceiling plenums
   c. Within walls
7. Install in a neat and workman-like manner.
8. Fasten flexible connections bridging cabinets and doors, neatly along hinge side.
   a. Protect against abrasion.
9. Tie and support the tubing neatly.
10. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system.
11. Do not install pneumatic devices or tubing where there is danger of freezing.

E. Equipment installed under other divisions of the specifications:

1. Furnish dampers, valves, thermostat wells, flow switches and other equipment to Installers at proper time.
2. Provide installation instructions.

F. Adjust low-leakage dampers so all gaskets and seals are properly compressed.

G. Provide outside air and relative humidity sensors at each outside air intake louvers for air handlers.

3.3 IDENTIFICATION

A. Devices Inside Panels: Either of the following:

1. Engraved labels.
2. Lettered in permanent ink with felt tip marker.

B. Exposed Devices: Engraved labels.

C. Location: On the body of the device or on the surface to which it is mounted.

1. Do not put identification on removable covers.

D. Label each remotely mounted control panel as to the device it controls.

3.4 OPERATING AMBIENT CONDITIONS

A. Electronic controls mounted in unconditioned space shall be rated for ambient operating conditions from -40°F to 155°F. Controls not meeting these limits shall be mounted in an accessible location within conditioned space.

B. Where controllers and other components are located in outdoor or unconditioned spaces provide cabinets with ventilation and/or electronic heaters where required to maintain temperature and moisture levels required for proper operation.

3.5 OWNER TRAINING

A. The BAS/ATC contractor shall provide 4 copies of an operator's manual describing all operating and routine maintenance service procedures to be used with the temperature control and Building Automation System supplied. This contractor shall instruct the owner's designated representatives in these procedures during the startup and test period. The owner training shall consist of a minimum of three (3) 8 hour instruction periods scheduled by the owner over the first 12 months of system operation. The training shall be scheduled during normal working hours.

B. Follow up training shall be provided under this Division for two (2) eight hour instruction periods at six months and twelve months after building acceptance.

C. Provide minimum 40 classroom hours of factory training in programming and use of the BMS/ATC system for each of two people (designated by Owner). Provide room and board for trainee's class during this period if factory is located more than 30 miles from the project. Provide this training no more than six months, and no less than eighteen months after building acceptance.

3.6 CALIBRATION AND ADJUSTMENTS

A. After completion of the installation, perform final calibrations and adjustments of the equipment provided under this contract and supply services incidental to the proper performance of the ATC and BAS system under warranty below.

3.7 OPERATION BY OWNER

A. Owner may require operation of part of the system prior to final acceptance. Operation is not to be construed as acceptance of work.

3.8 ACCEPTANCE PROCEDURE

A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative.

B. Upon completion of the calibration, Contractor shall startup the system and perform all necessary testing and run diagnostic tests to ensure proper operation. Installer shall be responsible for generating all software and entering all database necessary to perform the sequence of control and specified software routines. An acceptance test in the presence of the Owner's representative or Architect shall be performed.

1. If more than two of the first 10 devices tested, or more than 10% of the first 20 or more devices tested, fail to operate properly, the test shall be discontinued.
2. Additional testing, after corrections are made, shall be done at the Installer's expense.

C. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.

D. Field Equipment Test Procedures: DDC Zone and Local Controllers shall be demonstrated via a functional end-to-end test as follows:

1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operations verified.
2. All analog input channels shall be verified for proper operation.
3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.

E. Workstation Test Procedures: The System Workstation test procedures shall be as follows:

1. Communication with each DDC Zone and Local Controller shall be demonstrated.
2. Operator commands will be explained and demonstrated.

3. Control sequences shall be demonstrated for proper operation.
4. All available system reports and logs shall be demonstrated at the System Workstation.
5. Correct system start-up and shutdown procedures shall be demonstrated.
6. All controllers shall be demonstrated to operate in standalone mode.

F. Acceptance Test of Mechanical Systems

1. Perform at least two (2) operational tests of the entire mechanical system as described in Section 01700 of the specifications.
2. Give each element of the system an operating test of not less than 48 hours' duration to demonstrate to the satisfaction of the Architect that the control system is functioning properly and that the system is capable of producing the required environmental conditions. During this test, operate the system entirely on automatic control and take periodic readings of the inside and outside wet and dry bulb temperatures. Obtain wet and dry bulb temperatures with a recording thermometer-hygrometer. Conduct tests with outside temperature and humidity conditions as near design conditions as practical.
3. Winter acceptance test shall be conducted when outside temperatures are at or near 17°F, summer acceptance test shall be conducted when outside temperatures are at or near 95°F db.
4. Conduct tests during summer and winter outdoor temperature extremes as specified above. Notify Owner seven (7) days in advance of proposed tests.
5. Record temperature and humidity at an exterior and interior location for each system as designated by the Engineer at least once every hour for 48 hours during tests.
6. Submit a report detailing the following:
    a. Instrument used:
        1) Most recent calibration date.
    b. Date of tests.
    c. Description of test apparatus locations and methods.
    d. Results of tests.
    e. Any abnormal usage of the building or abnormal system characteristics observed during the course of the test.

3.9 RECORD DOCUMENTS

A. Electronic Media As-Built Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply complete 11X17 hard copy as-built drawing sets, together with diskettes to the owner. The number of hard copies shall be electronic media equal to the number of O&M manuals (Re: Division 1 and Division 20 01 01).

B. Operation and Maintenance Manuals: Submit Operation and Maintenance manuals (Re: Division 1 and Division 20 01 01). Include the following in each manual:

1. BMS/ATC information for insertion into the Manufacturer's catalog data and specifications on all sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.
2. An Operator's Manual which will include detailed instructions for all operations of the system.
3. An Operator's Reference Table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.

4. A Programmer's Manual which will include all information necessary to perform programming functions.
5. A language manual which will include a detailed description of the language used and all routines used by the system.
6. Flow charts of the control software programs utilized in the Temperature Control System.
7. Flow charts of the custom software programs utilized in the Temperature Control System.
8. Complete program listing file and parameter listing file for all programs.
9. A copy of the warranty.
10. Operating and maintenance cautions and instructions.
11. Recommended spare parts list.
12. Twelve (12) hour service phone number and point of contact.

3.10 WARRANTY

A. All BAS/ATC devices and installation shall be warranted to be free from defects in workmanship and material for a period of one year from the date of job acceptance by the owner. Any equipment, software, or labor found to be defective during this period shall be repaired or replaced without expense to the owner. Factory authorized warranty service shall be available within 50 miles of jobsite.

PART 4 - SEQUENCE OF OPERATION

4.1 GENERAL

A. BMS/ATC Contractor shall design, install, program, test, commission and demonstrate a complete and fully functional system capable of meeting the Sequences of Operation detailed below. Provide additional control points and functions as required, even if not specifically called for, if normally considered necessary for a BMS/ATC installation of the size and complexity of this project.

B. Listed items of equipment shall be individually controlled by standalone controller. Each controller shall serve only one individual unit. The unit controller shall be supplied by the BMS Contractor and may be furnished to the equipment supplier for factory mounting. The cost to mount, calibrate, program and test the controller and actuator shall be coordinated prior to bid day and included in the BMS price.

1. VAV Box.
2. Fancoil Unit.
3. Air Handling Units.
4. Rooftop Units.
5. Terminal Reheat Coil.
6. Desiccant Units.
7. Make Up Air Unit.
8. Environmental Fans.
9. Pumps.
10. Water Heaters.

C. Multiple units may be controlled by individual standalone controllers for all other control points.

D. Sensor and transducer installation, control power and wiring ad communications wiring shall be provided under this division by BMS/ATC Contractor.

E. Refer to the Systems Points List at the end of this division and equipment schedules on the drawings for required control inputs and outputs for each item of equipment listed in the Sequence of Operation.

4.2 OCCUPANCY SCHEDULES

A. The following special occupancy schedule types are here-by defined:

1. Event Occupancy: Based events scheduled by the Operator at the beginning of the season, and amended as necessary.
2. Player Occupancy: Based on days which will have player occupancy and the locker rooms will be utilized, but the rest of the facility may not.
3. Office Occupancy: Based on a normal office occupancy (including holidays and weekend scheduling, etc.), when neither Player nor Game Day occupancy occur.

B. Any device utilizing on/off control or scheduling shall be capable of being programmed to conform to any of these schedules.

4.3 DEFINITIONS

A. Primary or Production: Part of the circulation loop which directly flows through a chiller.

B. Secondary or Distribution: Part of the circulation loop which directly flows through terminal units.

4.4 SEQUENCE OF OPERATIONS

Refer to the Mechanical Control Diagram drawings for equipment sequence of operations.

END OF SECTION 230900

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This Section covers water piping carrying water at 200ºF or less, used in the following systems:

1. Heating system
2. Cooling system
3. Condensate drain system
4. Condenser water system

1.2 SUBMITTALS

A. Submit manufacturer's product data on the following:

1. Strainers
2. Expansion tanks
3. Air purgers
4. Air vents
5. Pressure reducing fill valves
6. Pressure temperature taps
7. Balancing valves
8. Thermometers
9. Flow indicating devices
10. Pot feeders
11. Automatic flow control valves
12. Relief valves
13. Glycol

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Size 2" and Smaller: Any of the following:

1. Steel pipe, Schedule 40 with 125-lb. cast iron threaded fittings.
2. Copper tube, hard temper, Type L with wrought copper fittings.
    a. Solder for copper tube joints:
        1) 30 psig to 175 psig: 95-5 tin antimony.
        2) Above 175 psig: Brazed joints.
    b. Grooved Copper

B. Size 2½" and Larger: Steel pipe, standard schedule, with any of the following fittings:

1. Black steel standard weight butt weld.
2. 125-lb cast iron flanged.

3. Malleable or ductile iron grooved pipe fittings, designed for roll or cut grooved joint (grooved piping 24" and larger to be Schedule 40).

2.2 PREINSULATED/BURIED PIPE

A. Pipe Materials: Pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight indicated for each service.

B. Pipe/Tube Fittings: Factory-fabricated fittings of type, materials, grade, class, and pressure rating indicated for each service and pipe size.

C. A preinsulated piping system consists of carrier pipe, insulation, protective jacket, connectors, supports and appropriate fittings.

D. All straight sections, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds. One square cut, plain end for field cutting and beveling is allowed per straight run of pipe. Other ends shall be factory square cut and factory beveled such that the field welds have the capability of being welded to pass x-ray testing.

E. The system design shall be in strict conformance with ASME/ANSI B31.1, latest edition, and stamped by a registered professional engineer.

F. Manufacturers:

1. Perma-Pipe/Ricwil
2. Thermal Pipe System
3. Thermacor

G. Accessories:

1. End seals, fittings and anchors shall be designed and factory fabricated to prevent the ingress of moisture into the system during shipping, outdoor storage, installation and operation. End caps on the ends of the service pipe are required to prevent debris from entering the pipe for the period of time up until installation.

H. Protective Jacket:

1. All straight sections of the factory preinsulated piping system shall be jacketed with a High Density Polyethylene jacket conforming to ASTM D1248. PVC jackets shall not be allowed.
2. All HDPE jacketing material shall have minimum wall thickness as specified below. The wall thickness shall not be less than indicated in these specifications.

Jacket O.D.	Jacket Thickness
O.D. ≤ 12"	0.125"
12", O.D. ≤ 24"	0.150"
O.D. 24"	0.175"

3. All fittings of the factory preinsulated piping system shall be jacketed with the same material used for the straight sections of pipe and prefabricated to minimize field joints. Fittings shall be jacketed using a molded HDPE cover over polyurethane foam. Fittings shall be waterproof from the factory without the use of any type of tape, cellophane (or other non-HDPE plastic) wrap, mastic, glue or hot air welds.

I. Field Joints:

1. All field joints shall be made in straight sections of pipe. Field joints other than at straight sections shall not be acceptable.
2. The method of field joint closure is as follows:
   a. The field joints are pressure tested and inspected for leaks.
   b. A split sleeve with holes in the top is placed around the joint area and secured with straps and sealed to the jacket with tape.
   c. Two-part polyurethane foam is mixed properly and poured into the holes on the top of the split sleeve.
   d. After the foam insulation has expanded and cured, any excess foam shall be removed.
   e. An adhesive backed heat shrinkable sleeve is then placed around the field joint area making sure to overlap the sleeve onto the HDPE jacketing by at least 3” on each side. This 3” overlap is to be completely on the HDPE and does not include the length of overlap of the split sleeve or tape.
   f. Heat is applied using a rosebud torch to the heat shrinkable sleeve slowly and evenly across the length of the sleeve until the sleeve has drawn tight.
   g. Any spots that pucker up during the shrinking process shall be covered with a thick-bodied asphaltic mastic (black roofing compound).
   h. Backfilling of the trench shall not begin until the area has cooled to the touch.
3. The piping systems manufacturer shall furnish all the foam insulation, split sleeves and heat shrinkable jacketing materials for making the field joints. The contractor shall furnish the straps, tape, knives, saws, torch, gas and mastic materials.

2.3 STRAINERS

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
   a. Mueller
   b. Sarco
   c. Hoffman
   d. Dunham Bush
   e. Gruvlok
   f. Victaulic

B. Size 2” and Smaller: 250-lb cast iron, threaded.

C. Size 2½” and Larger: 125-lb cast iron, flanged or grooved.

D. Screens:

1. Final Screen:
   a. Material: Type 304 stainless steel.
   b. Perforations: 0.045" diameter, 233 holes per square inch.
2. Roughing Screen:
   a. Material: Carbon steel.
3. Provide roughing screens at all circulation pumps and at any additional strainers upstream of primary plant equipment such as boilers, chillers, etc.

2.4 EXPANSION TANKS

A. Manufacturers:

1. Design Basis: ITT Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Taco
   b. GFC Corp
   c. J.J. Finnigan
   d. John Wood
   e. Wessels
   f. Apollo
   g. Amtrol

B. Design pre-charge pressure: Same as boiler make-up water PR fill valve.

C. Bladder or Diaphragm Material: EPDM, compatible with propylene glycol.

2.5 AIR PURGERS

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Amtrol
   b. Taco
   c. Thrush

B. Model: 107A

C. Float actuated, non-modulating, rated at 175 psig at 150 ºF and 150 psig at 250ºF.

2.6 AIR VENTS

A. Manufacturer:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Amtrol
   b. Taco
   c. Thrush

d. Armstrong

B. Resilient Parts: EPDM

C. Vents on Pipes Size 2" and Smaller: Model 4V

D. Vents on Pipes Size 2½" and Larger: Model 107A

E. Vents on Air Purgers: Model 97

F. Automatic Air Vents: Model 97

2.7 PRESSURE REDUCING FILL VALVES

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Taco
   b. Thrush
   c. Watts
   d. Apollo

B. Size: ¾"

C. Model:

1. 8 psig to 25 psig: No. 12
2. 25 psig to 60 psig: No. 7

2.8 PRESSURE TEMPERATURE TAPS

A. Manufacturers:

1. Design Basis: Sysco
2. Other Acceptable Manufacturers:
   a. Universal Lancaster, Inc.
   b. Petes Plug

B. Model: BNO-500, ¼" NPT, or ½" NPT.

C. Construction:

1. Body and Cap: Brass
2. Pressure: 500 psig
3. Temperature: 350ºF
4. Core: EPDM, self-sealing.
5. Cap: Gasketed, threaded.

D. Thermometer:

1. Number required: 1
2. Dial diameter: 2”
3. Range: 0º to 220º

E. Pressure Gauge Adapter:

1. Number required: 1
2. Model: GA-125

F. Pressure Gauge:

1. Number required: 1
2. Dial diameter: 4½”
3. Range: 0 to 100 psig
4. Accuracy: ½%

2.9 BALANCING VALVES

A. See Section 23 05 23.

2.10 THERMOMETERS

A. Manufacturers:

1. Design Basis: Trerice
2. Other Acceptable Manufacturers:
   a. Ernst
   b. Marsh
   c. Marshalltown

B. Housing: 9” adjustable angle stem.

C. Tube: Lens front, red liquid.

D. Range:

1. Chilled water, condenser water, 0ºF to 100ºF.
2. Hot water, 30ºF to 240ºF.

2.11 PRESSURE GAUGES

A. Design Basis: Trerice

1. Other Acceptable Manufacturers:
   a. Ernst
   b. Marsh
   c. Marshalltown

d. Winters

B. Model: 800LF Series. Liquid filled.

C. Dial Face 3½ inch diameter; 270º arc.

1. Range: As required to keep normal operating point in mid 2/3 to ¾ of dial.
   a. Use 30" vacuum to 100 psi gauge for pumps designed to operate at pressures up to 75 psig total pressure. (Total pressure = required pump-off static pressure plus scheduled pump head).
2. Use higher pressure ranges as required such that scheduled total pressure does not exceed an operating point above ¾ range of dial.

D. Accuracy: 1% of full scale over middle of range.

2.12 FLOW MEASURING DEVICES (ANNULAR/VELOCITY AVERAGING)

A. Manufacturers:

1. Design Basis: Veris
2. Other Acceptable Manufacturers:
   a. Presso

B. Accessories:

1. Stop valves
2. Quick disconnects
3. Caps

2.13 FLOW MEASURING DEVICES (TURBINE)

A. Manufacturers:

1. Design Basis: Onicon
2. Other Acceptable Manufacturers: Approved equivalent

2.14 POT FEEDERS

A. Manufacturers:

1. Design Basis: Neptune
2. Other Acceptable Manufacturers:
   a. Griswold
   b. J.L. Wingert
   c. Wessels

B. Model: VTF-2HP

C. Size: 2 gal.

2.15 AIR SEPARATORS

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Taco

B. Model: “Rolairtrol”

C. Constructed and nameplated for 125 psig working pressure and stamped in compliance with ASME boiler and pressure vessel code.

D. Provide blow-down connection.

2.16 AUTOMATIC FLOW CONTROL VALVES

A. Flows Under 3 gpm:

1. Manufacturers:
   a. Design Basis: Hayes
   b. Other Acceptable Manufacturers: None
2. Allowable Flow Variation: 15% maximum.
3. Pressure Drop Range: 15 to 150 psi.

B. Flows 3 gpm or Greater:

1. Manufacturers:
   a. Design Basis: Griswold
   b. Other Acceptable Manufacturers:
      1) Autoflow
2. Type: Spring loaded piston.
3. Materials and Connections: Match pipes.
4. Allowable Flow Variation: 5% maximum.
5. Pressure Drop Range: 2 to 40 psi.

2.17 RELIEF VALVES

A. Manufacturers:

1. Design Basis: Bell & Gossett
2. Other Acceptable Manufacturers:
   a. Taco
   b. Thrush
   c. Watts
   d. Apollo

B. Type: ASME

C. Size: Maximum input capacity of system at design pressure.

D. Setting: Operating pressure of system plus 2 psi.

2.18 PROPYLENE GLYCOL

A. Manufacturers:

1. Design Basis: Dow Chemical Company
2. Other Acceptable Manufacturers:
   a. Union Carbide
   b. Dupont

B. Model: Dowfrost

C. Type: Propylene Glycol based with corrosion inhibitors. Add inhibitors to provide recommended amounts for corrosion and microbial growth protection for systems with less than 30% glycol concentrations. Added inhibitors must be compatible with the glycol and its inherent inhibitors.

2.19 REDUCED PRESSURE BACKFLOW PREVENTER

A. See Section 221000.

2.20 VENTURIS

A. Manufacturers:

1. Gerand
2. Barco
3. Presso

B. Identification:

1. Provide engraved metal tag indicating Beta Ratio or flow curve.
2. Hang on chain to clear insulation.

C. Size:

1. Select Beta ratio to provide 10” to 30” water gauge meter reading.

2.21 COIL CONNECTION KITS

A. Manufacturers:

1. Basis of design: Victaulic 78Y/78U
2. Other Manufacturers:
   a. Hays.
   b. FDI.

B. Combination Y-Strainer, union, PT port, and ball valve

1. 400 psi maximum CWP, available as sweat x sweat; sweat x female threaded; female threaded x sweat; female threaded x female threaded; DZR brass body consisting of a full port ball valve and strainer with flow measuring ports.
2. Ball valve shall be complete with double 0-ring seal, plated ball, blow-out proof stem, and steel handle with vinyl grip. Strainer shall be Y-pattern, with 20 mesh stainless steel screen and blow-down port. Strainer/ball combination shall provide a simplified hookup to protect the coil and modulating valve. To be suitable for operating temperatures up to 230'F.

C. Coil Hoses

1. 375 psi maximum CWP (varies by size), stainless steel braided hose and a synthetic polymer core with stainless ferrules; available as male by female swivel and male by male swivel and in three lengths: 12", 24" or 36". Suitable for operating temperatures up to 230 degrees F.
2. Install hoses free of kinks and coordinated with other equipment/accessories.
3. Hoses shall be insulated to meet requirements of 23 07 00 (Mechanical Insulation).
4. Provide air vents at all high points in piping systems. If the rigid pipe connection to the hose is higher than the coil air vent, provide additional air vent at high point.

D. Combination Union Port fitting with PT Port and Manual Air Vent

1. 400 psi maximum CWP, available as sweat x male threaded; female threaded x male threaded; DZR brass body with manual air vent port and pressure/temperature port, with EPDM seals. Union port fitting shall provide a simplified terminal hookup for installation at coil outlets. Suitable for operating temperatures to 230'F.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. Install horizontal piping level (except drain piping and as otherwise noted) and parallel to building construction. All vertical piping to be plumb.

B. Make any changes in direction with fittings, do not kink or bend piping. Elbows are to be long radius type wherever possible.

C. Where pipes pass expansion joints or structural elements subject to movement, provide flexible expansion compensators and supports or piping expansion loops to allow for movement without adverse effects.

D. Regardless of how shown on schematic piping diagrams, do not install a tee so that flow enters from opposite directions.

E. Do not rearrange piping in a manner to increase pressure drop without written approval from Architect/Engineer.

F. Install drains at all low points of the system.

3.2 EQUIPMENT CONNECTIONS

A. Do not allow weight of piping or expansion of piping to put stress on equipment connections.

B. Pipe equipment to allow for servicing (coil pull, tube pull, etc.) with minimum of disruption to piping.

C. Provide unions or flanges at all equipment connections.

3.3 FREEZE PROTECTION

A. Fill systems with indicated solution by volume of propylene glycol and water.

B. Pre-mix all solutions before injection into system.

3.4 AIR VENTS

A. Install automatic air vents at high points in equipment rooms.

B. Install manual air vents at high points not in equipment rooms.

3.5 RELIEF VALVES

A. Install pressure relief valves on all vessels, which may be isolated from other relief valves by closing valves. Pipe discharge full size to nearest floor drain.

3.6 PRESSURE TEMPERATURE TAPS

A. In Pipes 2” and Smaller: Install taps in tee at change in direction so inserted thermometer stem will be parallel to center line of pipe.

1. Add extra change in direction if necessary.
2. Allow clearance for insertion of thermometer.
3. Insure that gauge or thermometer will be in a readable position.

3.7 HOT TAPS

A. Hot taps are to be used only after written permission by the Architect/Engineer. Submit intended procedure with request.

3.8 CLEANING

A. Flush the system thoroughly with clear water.

1. Drain system.
2. Clean all strainers.

B. Refill system with solution of 1 lb. trisodium phosphate to 50 gal of system water.

1. Heat system to design temperature.
2. Circulate as required to fully clean the piping system. Continuously check strainers and verify they have been clean for a minimum of two hours.
3. Stop circulation and drain system.
4. Clean all strainers.

C. Fill system with fresh water or water/glycol mixture.

3.9 CORROSION PROTECTION

A. Provide dielectric unions at unions between piping of different materials.

B. See Section 23 25 13 for water treatment program to be provided.

C. All components of system shall be compatible with propylene glycol and water solution.

3.10 PREINSULATED/BURIED PIPE

A. Provide closed cell insulation, seal joints with waterproof mastic. Minimize joints below grade.

B. Provide thrust blocks at all changes in direction for pipe 8” and larger.

C. Comply with Division 2 and Section 23 05 03 for excavation and backfill requirements.

D. The installing contractor shall handle the system in accordance with the directions furnished by the manufacturer and as approved by the engineer.

E. A minimum of six inches (6”) of sand or fine gravel bedding shall be placed all around the pipe in the trench. This bedding/fill shall be hand tampered and compacted around the pipes in six inch (6”) lifts until the fill is six inches (6”) above the top of the jacketing material. The remaining height of the trench shall be evenly and continuously backfilled and compacted in uniform six inch (6”) lifts with suitable clean excavated soil.

3.11 PRESSURE GAUGES

A. Pump assemblies: Use a single gauge with multiple taps to pumped system (strainer inlet, strainer outlet, pump suction and pump discharge) per the detail on the drawings.

B. Allow clearance for removal of gauge.

C. Insure that gauge will be in a readable position.

END OF SECTION 232113

SECTION 23 2123 - HVAC PUMPS

PART 1 - GENERAL

1.1 MOTOR HORSEPOWER

A. Do not increase or decrease motor horsepower from that specified without written approval from Architect/Engineer. See Section 23 05 01.

B. Select pumps so that for single pump application at a minimum, brake horsepower does not exceed motor horsepower at rating point, and does not exceed motor horsepower plus service factor on impeller curve at 125% rated flow. For parallel pump application motor horsepower shall be selected such that pump can operate at any point on the pump curve without overloading.

1.2 SUBMITTALS

A. Manufacturers Product Data: Submit manufacturer's product data on pumps.

1. Include pump curve and mark rating point. Also include single pump operating point for a parallel pump application.
2. Show maximum allowable operating temperature and pressure.
3. Note in red any deviations from specified construction.
4. Show impeller diameter indicate maximum impeller diameter for pump volute provided, and indicate if impeller is machined down.

PART 2 - PRODUCTS

2.1 IN-LINE CIRCULATOR FOR HEATING (Small - Horizontal Motor)

A. Manufacturers:

1. Design Basis: Grundfos/Paco
2. Other Acceptable Manufacturers:
   a. Taco
   b. Armstrong
   c. Aurora
   d. Bell & Gossett

B. Design Conditions:

1. Pressure: 125 psig
2. Temperature: 225ºF

C. Construction:

1. Motor Mount: Resilient.
2. Bearings: Sleeve, bronze, oil lubricated.

3. Casing: Cast iron.
4. Impeller: Steel, cadmium plated, cast iron, or bronze.
5. Shaft: Steel with copper sleeve or stainless steel.
6. Seal: Mechanical.
7. Coupler: Spring or flexible sleeve.

2.2 LARGE INLINE PUMPS (Vertical Motor)

A. Manufacturers:

1. Design Basis: Grundfos/Paco
2. Other Acceptable Manufacturers:
   a. Armstrong
   b. Taco
   c. Allis Chalmers
   d. Dunham Bush
   e. Peerless
   f. Aurora
   g. Bell & Gossett

B. Construction:

1. Pump Body: Cast Iron, Double or Single suction as shown on drawings. Provide mounting pedestal or bolt circle for flange where floor support is required.
2. Impeller: Bronze, enclosed.
3. Shaft: Steel with bonze sleeve or stainless steel.
4. Shaft Seal: Mechanical, internally flushed, carbon-ceramic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Install pumps to allow complete removal without dismantling connecting piping.
2. Provide air cock and drain connection on pump casing.
3. Decrease from line size with long radius reducing elbows or concentric reducers, or suction diffusers.
4. Support piping adjacent to pump so that no weight is carried on pump casings.
5. Comply with manufacturers recommendations for support of inline pumps. Provide support for motors when mounted horizontally. Verify Manufacturer's allowable motor position and install accordingly.
6. Provide supports under elbows on pump suction and discharge line.
7. Provide one pressure gauge with piping and gauge cock to measure pressure of strainer inlet, pump suction, and pump discharge.
8. Manufacturer's representative shall verify proper pump operation.

B. Motor Mount – Inline Pumps:

1. Verify motor position (vertical or horizontal) with manufacturer's installation instructions.
2. Provide proper pump support in accordance with manufacturer's installation instructions. Do not support pump from equipment.
3. Provide adequate clearance around pump for motor and shaft removal.

C. Lubrication: After completion of the system and before start-up, lubricate the pumps.

D. Impeller Trim: Remove impeller and machine down if more than 25% of the total pump head must be throttled by the pump discharge valve.

E. For inline pumps with motors 7.5 HP and larger, provide a suitable lifting point (eye bolt, strut channel) directly over the motor to aid in removal of the rotating element.

F. Pipe drip pan base to floor drain.

END OF SECTION 232123

SECTION 23 2124 – VARIABLE SPEED PUMPING SYSTEM

PART I – GENERAL

1.1 WORK INCLUDED

A. Variable Speed Packaged Pumping System

1.2 REFERENCE STANDARDS

The work in this section is subject to the requirements of applicable portions of the following standards:

A. Hydraulic Institute

B. ANSI – American National Standards Institute

C. ASTM – American Society for Testing and Materials

D. IEEE – Institute of Electrical and Electronics Engineers

E. NEMA – National Electrical Manufacturers Association

F. NEC – National Electrical Code

G. ISO – International Standards Organization

H. UL – Underwriters Laboratories, Inc.

PART 2 – PRODUCTS

2.1 VARIABLE SPEED PACKAGED PUMPING SYSTEM WITH INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS

A. Furnish and install a pre-fabricated and tested variable speed packaged pumping system capable of varied water flow.

B. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed and built by the same manufacturer. The variable speed packaged pumping system shall be by Grundfos, or Engineer approved equal.

2.2 PUMPS

A. The pumps shall be of the in-line vertical multi-stage design.

B. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

C. D.Small Vertical In-Line Multi-Stage Pumps (Nominal flow from 3 to 125 gallons per minute) shall have the following features:

1. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.
2. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.
3. Pump Construction.
   a. Suction/discharge base, pump head, motor stool: Cast iron (Class 30)
   b. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
   c. Shaft 316 or 431 Stainless Steel
   d. Impeller wear rings: 304 Stainless Steel
   e. Shaft journals and chamber bearings: Silicon Carbide
   f. O-rings: EPDM

   Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron (ASTM 60-40-18).

   Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.
4. The shaft seal shall be a balanced o-ring cartridge type with the following features:
   a. Collar, Drivers, Spring: 316 Stainless Steel
   b. Shaft Sleeve, Gland Plate: 316 Stainless Steel
   c. Stationary Ring: Silicon Carbide
   d. Rotating Ring: Silicon Carbide
   e. O-rings: EPDM

   The Silicon Carbide shall be imbedded with graphite.
5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

E. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 500 gallons per minute) shall have the following features:

1. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.
2. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.
3. Pump Construction.
   a. Suction/discharge base, pump head Ductile Iron (ASTM 65-45-12)
   b. Shaft couplings, flange rings: Ductile Iron (ASTM 65-45-12)
   b. Shaft 431 Stainless Steel
   c. Motor Stool Cast Iron (ASTM Class 30)
   d. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
   e. Impeller wear rings: 304 Stainless Steel

f. Intermediate Bearing Journals: Tungsten Carbide
g. Intermediate Chamber Bearings: Leadless Tin Bronze
h. Chamber Bushings: Graphite Filled PTFE
I. O-rings: EPDM

4. The shaft seal shall be a single balanced metal bellows cartridge with the following construction:
   a. Bellows: 904L Stainless Steel
   b. Shaft Sleeve, Gland Plate, Drive Collar: 316 Stainless Steel
   c. Stationary Ring: Carbon
   d. Rotating Ring: Tungsten Carbide
   e. O-rings: EPDM
5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

2.3 INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS

A. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.

B. The VFD shall be of the PWM (Pulse Width Modulation) design using current IGBT (Insulated Gate Bipolar Transistor) technology.

C. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

D. The VFD shall utilize an energy optimization algorithm to minimize energy consumption. The output voltage shall be adjusted in response to the load, independent of speed.

E. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.

F. An integral RFI filter shall be standard in the VFD.

G. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

H. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.

I. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

J. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:

1. Speed Reference Signal: 0-10 VDC, 4-20mA
2. Digital remote on/off
3. Fault Signal Relay (NC or NO)
4. Fieldbus communication port (RS485)

K. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a temperature rise no higher than Class B.

L. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.

M. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

2.4 PUMP SYSTEM CONTROLLER

A. The pump system controller shall be a standard product developed and supported by the pump manufacturer.

B. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a VGA display with a minimum screen size of 3-1/2” x 4-5/8” for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.

C. The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

D. The controller shall display the following as status readings from a single display on the controller (this display shall be the default):

1. Current value of the control parameter, (typically discharge pressure)
2. Most recent existing alarm (if any)
3. System status with current operating mode
4. Status of each pump with current operating mode and rotational speed as a percentage (%)

E. The controller shall have as a minimum the following hardware inputs and outputs:

1. Three analog inputs (4-20mA or 0-10VDC)
2. Three digital inputs
3. Two digital outputs
4. Ethernet connection
5. Field Service connection to PC for advanced programming and data logging

F. Pump system programming (field adjustable) shall include as a minimum the following:

1. Water shortage protection (analog or digital)
2. Transducer Settings (Suction and Discharge Analog supply/range)
3. PI Controller (Proportional gain and Integral time) settings
4. High system pressure indication and shut-down
5. Low system pressure indication and shut-down
6. Low suction pressure/level shutdown (via digital contact)
7. Low suction pressure/level warning (via analog signal)
8. Low suction pressure/level shutdown (via analog signal)
9. Flow meter settings (if scheduled, analog signal)

G. With additional input/output modules, the system controller shall be able to accept up to seven closed loop programmable set-points and seven open loop programmable set-points.

H. The controller shall have advanced water shortage protection. When analog sensors (level or pressure) are used for water shortage protection, there shall be two indication levels. One level is for warning indication only (indication that the water level/pressure is getting lower than expected levels) and the other level is for complete system shut-down (water or level is so low that pump damage can occur). System restart after shut-down shall be manual or automatic (user selectable).

I. The system set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).

J. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

K. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

High System Pressure	Low system pressure
Low suction pressure (warning and/or alarm)	Individual pump failure
VFD trip/failure	Loss of sensor signal (4-20 mA)
Loss of remote set-point signal (4-20mA)	System power loss

L. The pump system controller shall be mounted in a NEMA 4 enclosure (NEMA 3R if cooling fan is required). The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.

<u>Control panel options shall include, but not be limited to:</u>

Pump Run Lights	Pump Alarm Lights
System Fault Light	Audible Alarm (80 db[A])
Surge Arrestor	Control Panel Internal Illumination
Emergency/Normal Operation Switches	Service Disconnect Switches

M. The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor.

N. The controller shall have a pump "Test Run" feature such that pumps are switched on during periods of inactivity (system is switched to the "off" position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (2-3) seconds every 24 hours, 48 hours or once per week (user selectable).

O. The controller shall be capable of providing instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours) when connected to integrated VFD motors through the field bus.

P. The actual pump performance curves (5^{th} order polynomial) shall be loaded (software) into the pump system controller.

2.5 SEQUENCE OF OPERATION

A. The system controller shall operate equal capacity variable speed pumps to maintain the system set point differential pressure. The system controller shall receive an analog signal [4-20mA] from the factory installed flow transducer on the discharge manifold, indicating the actual system flow. When the operating pump(s) reach 96% of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. When the system flow is equal to the system set-point all pumps in operation shall reach equal operating speeds. When all pumps in operation are running at low speed the system controller shall switch off pumps when fewer pumps are able to maintain system demand.

B. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

2.6 SYSTEM CONSTRUCTION

A. The suction and discharge manifolds shall be constructed of 316 stainless steel. Manifold connection sizes shall be as follows:

3 inch and smaller: Male NPT threaded
4 inch through 8 inch: ANSI Class 150 rotating flanges
10 inch and larger: ANSI Class 150 flanges

B. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.

B. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2" and small-

er shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2" and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.

C. For systems that require a diaphragm tank, a connection of no smaller than ¾" shall be provided on the discharge manifold.

D. A pressure transducer shall be factory installed on the discharge manifold (or field installed as specified on plans). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

E. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.

F. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.

G. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and baseframe to minimize vibration.

H. Depending on the system size and configuration, the control panel shall be mounted in one of the following ways:

On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
On a 304 stainless steel fabricated skid, separate from the main system skid
On its own base (floor mounted with plinth)

I. All equipment shall be mechanically braced for an available fault of no less than 65,000 amps.

PART 3 – EXECUTION

3.1 TESTING

A. The entire pump station shall be factory performance tested as a complete unit prior to shipment. Job-site programming shall be entered into the controller prior to shipment (details of installation requirements shall be communicated to the pump system manufacturer). A verified performance test report shall be made available from the system manufacturer.

B. The system shall undergo a hydrostatic test of 250 psig for a minimum of 15 minutes prior to shipment.

C. Start-up and Owner training shall be performed by the supplier.

3.2 WARRANTY

A. The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.

END SECTION 232124

SECTION 23 2300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Installer: A firm with at least five years of successful installation experience on projects with refrigerant piping similar to that required for this project.

1.2 REGULATORY/REQUIREMENTS

A. Comply with applicable requirements of the Clean Air Act, District of Columbia Regulations concerning handling of refrigerants.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

A. Type ACR copper tube with wrought copper fittings.

B. End Caps:

1. Provide factory applied plastic end caps on each length of pipe and tube.
2. Maintain end caps through shipping, storage and handling as required to prevent pipe end damage and eliminate dirt and moisture from inside of pipe and tube.

2.2 SHUT-OFF VALVES

A. Manufacturers:

1. Design Basis: Henry
2. Other Acceptable Manufacturers:
    a. Mueller
    b. Superior
    c. Imperial

B. Size 7/8 Inch and Smaller:

1. Model: Series 600.
2. Type: Pack-less diaphragm.
3. Material: Forged bronze.
4. Flow: Non-directional.
5. Servicing: Diaphragm changeable under line pressure.

C. Size 1-1/8 Inch and Larger:

1. Model: Series 200.

2. Type: Wing cap, back seating.
3. Material: Bronze.

2.3 FLEXIBLE PIPE CONNECTORS

A. Manufacturers:

1. Design Basis: Mason
2. Other Acceptable Manufacturers:
   a. Metraflex
   b. Flexonics

B. Braided bronze with copper tube ends, compatible with refrigerant type for system

C. Flexible connector shall be line size or connection size, whichever is larger.

2.4 REFRIGERATION SPECIALTIES

A. Filter Drier:

1. Conform to ARI Standard 710.
2. Sizes ½" and larger - interchangeable core, full flow.
3. Sizes smaller than ½" - sealed type.
4. Minimum burst pressure - 1500 psig.

B. Sight Glass:

1. Double port moisture indicating, reversible color indicator.
2. Removable sight glass and moisture indicating element.
3. Furnish with a protective cover.

C. Expansion Valve:

1. Thermostatic type, diaphragm or bellows operated.
2. External superheat adjustment factory set for 10ºF superheat (adjustable).
3. Compatible with refrigerant type for the project.
4. Pressure rated per project requirements.
5. Power elements and valve size shall be as recommended by the manufacturer, for the service intended.

D. Solenoid Valve:

1. Provide solenoid valve for systems 25 tons and larger.
2. Compatible with refrigerant type for the project.
3. Valve shall fail in closed position (power open).

E. Acceptable Manufacturers:

1. Alco
2. Sporlen

PART 3 - EXECUTION

3.1 INSTALLATION

A. Run piping level or plumb, except slope gas piping to compressor with a minimum number of elbows.

B. Provide oil traps at bottom of suction risers. Size risers for proper oil return.

C. Size lines for total pressure drop not to exceed 2ºF saturation temperature.

D. Provide necessary flexibility for vibration and expansion with offsets and loops, not expansion joints.

E. Provide flexible connectors at all unit connections.

F. Replace air in pipe with dry nitrogen to prevent corrosion during soldering.

G. Install valves, sight glasses, filter-driers, and accessories, furnished by equipment supplier, but not factory installed.

H. Insulate all underground refrigerant lines with ½" flexible foam.

1. Use un-slit covering.
2. Carefully cement all joints.

3.2 HANGERS

A. For insulated piping, provide hangers of size to fit outside insulation.

B. For non-insulated piping, provide hangers with elastomer insert to prevent damage to piping from vibration.

3.3 TESTING AND DEHYDRATION

A. Use the following procedure to test and hydrate the systems:

1. Isolate any elements which would be damaged by test pressures.
2. Test system with trace gas using an appropriate leak detector.
3. Repair or replace leaking elements of system and re-test.
4. After system has been proven to be free of leaks, evacuate it with a high efficiency vacuum pump to 2.5 mm of mercury absolute.
5. Allow the system to stand under vacuum for 24 hours.
   a. Then, if a vacuum of 2.5 mm can be drawn within 30 minutes, the system shall be considered dry.
   b. If not, the procedure shall be repeated.
6. Break the final vacuum by charging with the correct refrigerant.

END OF SECTION 232300

SECTION 23 2513 - HVAC SYSTEM CHEMICAL TREATMENT

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install chemical treatment systems for closed hydronic systems where shown on the Drawings and as specified in this section.

B. Work under this section shall include providing equipment, chemicals, and service related to alter treatment for the chilled and heating water systems.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 23 05 21 Pipe and Pipe Fittings.

B. Section 23 21 13 Hydronic Piping.

1.3 QUALITY ASSURANCE

A. The chemical treatment program shall be administered by a firm regularly engaged in the field of water treatment with a minimum of five years experience in the immediate area of the job site location, and similar sized projects.

B. The water treatment contractor shall have laboratory facilities, both central and field, to service the Owner’s account.

C. The water treatment contractor shall have local warehousing and will not be allowed to overstock chemical on premises.

D. A single water treatment company shall be responsible for all products and services.

1.4 SUBMITTALS

A. Provide product data for each piece of equipment installed the system and for each chemical used.

B. Provide shop drawings for control panel, including internal and external wiring diagrams, dimensions, etc.

C. Provide operation and maintenance manuals for all equipment.

D. Material Data Safety Sheets shall accompany all chemicals delivered to the job site.

PART 2 - PRODUCTS

2.1 PRE-STARTUP CLEANER

A. Furnish pre-startup liquid detergent dispersant cleaner for flushing and cleaning of water systems to remove oil and foreign matter from piping and equipment prior to final filling of systems. Chemical shall not be injurious to persons, piping, pipe joint compounds, packings, coils, valves, pumps, and their mechanical seals, tubes, or other parts of the system.

B. Furnish complete instructions dictating quantities of cleaner to use, method of cleaning, duration or operation.

2.2 CHEMICALS

A. A buffered Molybdate and/or Nitrite based corrosion inhibitor shall be provided to initially treat the closed systems and added as required for 1 year from date of owner acceptance. This treatment must contain a copper inhibitor and a borate buffer.

B. Any treatment must be compatible with glycol installed in glycol/water systems.

2.3 POT FEEDER

A. Provide a five (5) gallon pot feeder piped around the main Hot Water and Chilled Water circulating pumps as indicated on the drawings. The feeder shall consist of a steel tank with operating pressure of 200 psi. A 3½" quick open cap with "O" ring seal shall be provided to add water treatment chemicals.

2.4 COUPON HOLDER

A. Provide coupon rack with coupon holders, flow control and isolation valves. Coupon racks shall be installed in all closed and open systems that are being treated.

B. Coupon Holders shall be similar to Pulsafeeder, Inc. Model CCR-4.

C. The Water treatment contractor shall install the coupons in the coupon holders and submit a written report to the Owner at the end of each 90 days, during the one year warranty period as to the condition of each system being treated.

2.5 CLOSED SYSTEMS – GLYCOL FEEDER

A. Glycol Feeder Assembly

1. Provide and install equipment for the automatic feed of a glycol solution. System components shall be as specified.
2. Glycol feeder shall be a packaged system consisting of a storage tank assembly, positive displacement pump, control panel, pressure relief valve, adjustable pressure switch, and low level switch.
3. Feeder storage tank assembly shall consist of one (1) 50 gallon polyethylene tank with cover equipped with two (2) 3/4" bulkhead fittings located 3" from the bottom of the tank for pump suction and drain. The storage tank shall be mounted on a steel tank stand equipped with a side mounting platform for the glycol pump. Tank and stand assembly

shall be Neptune G-50-1 or equal.

4. Glycol control panel with red low level warning light, alarm bell, alarm silence switch and hand/off/auto switch, prewired with terminal strip connections in NEMA 4X enclosure.
5. Pressure relief valve which shall be set at **75 psi**, with relief setting adjustable up to **100psi** with an Allen wrench. Pressure relief valve shall be Neptune Model RV316-1 or equal.
6. Pressure switch for glycol pump control shall be adjustable to provide glycol pump start/stop. Ranges: 5 to 65 psi differential 12 psi – Furnas Model 69WA4.
7. Low level drum caddy shall shut off glycol pump in the event of low glycol level in storage tank. Caddy shall be wired for pump disconnect and warning device activate circuits, and shall be LMI Low Level Switch.

B. Glycol: An inhibited industrial grade propylene glycol shall be furnished for proper percentage of glycol solution within the system. Refer to Section 23 21 13 for glycol requirements.

C. Test Equipment: Furnish a hydrometer type test kit for the determination of percent/freeze point of propylene glycol solutions.

PART 3 - EXECUTION

3.1 Provide a one year supply, from date of startup, of the recommended formulas for the prevention of scale, corrosion, and biological growth in the recirculating system.

3.2 All formulations must be compatible with system construction materials and meet or exceed all environmental requirements.

3.3 The water treatment company will supply all testing equipment and reagents, necessary to properly maintain the treatment program.

3.4 The water treatment company will provide a water treatment service program for a period of one year from system startup. This program shall include: startup assistance, plant personnel training, monthly service calls and inspection of system equipment. Provide owner with copy of field service report including performance test required levels vs. Field measurements.

3.5 Provide quarterly laboratory analysis and report of coupons.

END OF SECTION 232513

SECTION 23 2515 - CENTRIFUGAL SEPARATOR (Alternate 1)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged Separator system:

1. Structural steel base.
2. Pump and motor.
3. Piping, valves, fittings and specialties.
4. Controls, combination starter/disconnect.
5. Centrifugal separator.
6. Liquid recovery system.
7. Pressure gauges.

1.2 RELATED SECTIONS

A. Section 23 05 02 – Basic Mechanical Requirements

B. Section 23 05 21 - Pipe and Pipe Fittings

C. Section 23 05 23 - Valves

D. Section 23 05 13 - Motors, Starters and Variable Frequency Drives

E. Section 23 21 23 - HVAC Pumps

1.3 REFERENCES

A. Hydraulic Institute

B. ANSI, ASME

1.4 SUBMITTALS AND OPERATION MANUALS

A. Submittals shall include the following as a minimum:

1. Description of system operation.
2. Packaged system dimensions and general arrangement drawings.
3. Electrical power and control wiring diagram.
4. Pump material and construction.
5. Pump curve.
6. Catalog information on valves, strainers, gauges, control components.

B. Submittals which are generic and not specifically designed to meet the requirements of this project shall not be acceptable.

C. Provide O & M manuals per Division 1.

1.5 QUALITY ASSURANCE

A. Entire separator packaged shall be U.L. or E.T.L. listed per District of Columbia requirements and bear the label prior to shipping from the factory.

B. After factory assembly the packaged system shall be hydrostatically tested to 150 psig to a minimum of 1 hour.

1.6 DELIVERY OF EQUIPMENT

A. The entire packaged system shall be factory assembled and shipped as a complete unit.

B. Comply with manufacturer's instructions for rigging, unloading and transporting.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Design Basis: Lakos Model IC-2000-CRS.

B. Other manufacturers must submit product information prior to purchase.

2.2 GENERAL

A. Furnish and install a complete packaged centrifugal separator including all components listed in this section.

B. Unit shall perform per scheduled capacities.

2.3 PIPING

A. Conform with Section 23 05 21 requirements.

2.4 VALVES AND SPECIALTIES

A. Conform with Section 23 05 23 requirements

B. Pump specialties shall be detailed on plans for typical end suction pumps.

C. Butterfly valves shall be used for isolation.

2.5 MOTORS

A. Motors shall be high efficiency type, in accordance with Section 23 05 13.

2.6 PUMP

A. Pump specialties arrangement shall conform to the End Suction Pump Detail on the plans.

2.7 CENTRIFUGAL SEPARATOR

A. Separator shall be steel with 0.25" steel and 0.19" head.

B. Flanges shall be 150 pound Class D.

C. Separator shall meet ASME Section VIII, Division 1 standards. ASME certification shall be identified on the separator today.

D. Pressure gauge ports shall be provided at the inlet and outlet of the separator.

2.8 LIQUID RECOVERY TANK

A. Tank shall be constructed of minimum 3/16" carbon steel with internal epoxy coating. Lid shall be ¾" steel.

B. Basket shall be stainless steel.

C. Purge collection bag shall be polyester-felt material, 50 micron rating.

D. Air relief shall be right-angle push button type.

E. Include optional indicator package:

1. Bronze body stainless steel isolation ball valves.
2. Sight glass at inlet and outlet.
3. Pop-up style annunciator with contacts for B.M.S. monitoring.

2.9 POWER WIRING

A. All power wiring shall be in accordance with U.L. NEC requirements including branch circuit and single point connection overcurrent protection, separation of conductors and materials requirements.

B. Starter shall be combination type as specified in Section 23 05 13. Provide auxiliary contacts to allow on/off control via B.M.S. system.

2.10 FINISHING

A. All steel parts shall be cleaned, degreased and painted with a rust preventive primer.

B. The complete packaged system shall be painted with machine enamel prior to shipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install packaged system in accordance with manufacturer's instruction.

B. Contractor shall align pump and motor shifts to within manufacturer's recommended tolerances and in accordance with Section 23 21 23 prior to start up and re-check after 100 hours of operation.

END OF SECTION 232515

SECTION 23 2516 - CONDENSER WATER TREATING SYSTEM (Alternate 1)

PART 1 - GENERAL

1.1 QUALITY CONTROL

A. Installer:

1. A firm with at least five years of successful installation experience on projects with water treating systems similar to that required for this project.

B. Electrical Standards:

1. Provide electrical products which have been tested, listed and labeled by U.L.
2. Comply with NEMA standards.

C. Chemical Standards:

1. Provide chemical products acceptable under state and local pollution control regulations.

1.2 SUBMITTALS

A. Submit the following:

1. Manufacturer’s data on materials and equipment.
2. Operating instructions for:
   a. The system
   b. The water test kits
3. Certified test reports for samples.
   a. Comply with ASTM D 596 for reporting.
   b. Indicate ASTM test method used for each test.
4. Shop drawings showing:
   a. Piping
   b. Valves
   c. Connections

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide condenser water treating system manufacturer’s standard materials and components as indicated by his published product information, and as recommended by the manufacturer for the application indicated.

2.2 OPERATION

A. System shall automatically control chemical feed and bleed off.

2.3 PERFORMANCE

A. Provide system sized and equipped to treat raw water available at the project site to maintain the following condenser water characteristics:

1. Hardness: 500 ppm or less
2. Iron: 0.5 ppm or less
3. Total Alkalinity: 1026 ppm or less
4. Silica: 110 ppm or less
5. Total Algae: 0.00 growth
6. pH: 8 or above
7. Corrosion: 4 mils or less per year for low carbon steel

2.4 CHEMICAL EQUIPMENT MANUFACTURERS

A. Acceptable Manufacturers:

1. Nalco
2. Lakewood
3. Pulsafeeder
4. Advantage
5. Beta/HyDac
6. Autorol

2.5 EQUIPMENT

A. Bleed-Off Controller:

1. Type: Solid state conductivity monitor with flow through electrode assembly.
2. Selector Switch:
   a. Low range of 50-to-1,000 micromhos.
   b. High range of 1,000-to-10,000 micromhos.
3. Meter: Visual readout of conductivity.
4. Relay: Operates bleed-off valve.
5. Enclosure: NEMA 4X.
6. Pressure Switch: Shuts down controller when tower pump stops.

B. Bleed-Off Valve:

1. Type: Slow closing solenoid.
2. Size: 2 inch.

C. Bleed-Off Flow Rate Valve:

1. Manufacturers:
   a. Design Basis: Griswold.
   b. Other Acceptable Manufacturers:
      1) Aquaduct.
      2) Tasco

3) Hayes

2. Type: Spring loaded piston
3. Materials and Connections: Match pipes
4. Allowable Flow Variation: 5% maximum
5. Pressure Drop Range: 2 to 40 psi.
6. Flow: 60 gpm.

D. Brominator:

1. Manufacturer: Great Lakes
2. Model: CT8-28
3. Pressure: 120 psig

E. Chemical Pump:

1. Manufacturer: Liquid Metronics, or equal.
2. Model: Series A Simplex chemical pump, variable output.
3. Mounting: Steel wall bracket.

F. Brominator Injection Assembly:

1. Manufacturer: Neptune
2. Model: 2011

G. Injection Assembly:

1. Manufacturer: H-O-H
2. Model: 2011

H. Bypass Feeder:

1. Manufacturer: H-O-H, or equal
2. Model: AV
3. Size: Five gallon

I. Make-Up Flow Meter:

1. Manufacturer: Carlon, Badger
2. Type: Turbine with electric contact head
3. Rating: 350 gpm at 1-150 psi

J. Chemical Feed Timer:

1. Type: Reset timer, o-10 min. range minimum
2. Interlock with make-up flow meter to operate chemical feed pump.

K. Corrosion Cupon Rack

1. Four station type: 2 low carbon steel
   2 copper

2.6 CHEMICALS

A. Scale and Corrosion Control

1. Type: Non-acid, organophosphonate, multi-purpose liquid.
   a. Approved by local water pollution control authorities.
2. Furnish chemicals for first year of operation beginning at Owner acceptance.
3. Furnish chemicals in container suitable for use as solution reservoirs.

B. Algae Control

1. Provide two separate algaecides for alternate use.
   a. Furnish for first year of operation.

C. Test Equipment: Provide a metal test cabinet with lock and acid-resistant enamel finish, suitable for wall mounting. Cabinet shall be equipped with:

1. Titration test sets for determination of:
   a. Alkalinities
   b. Hardness
   c. Chlorides
   d. Sulfite
      1) Titration sets shall be equipped with:
         a) 10 ml burettes.
         b) 160 oz. Squeeze type polyethylene reagent bottles.
2. Taylor comparator sets for the determination of phosphate and pH.
3. Drop type test sets for the determination of inhibitor levels in condenser cooling water and closed recirculating systems.
4. Triple-range conductivity test set.

2.7 FILTRATION

A. Filter system shall consist of a vessel with a single permanent media (sand), a pre-filter with removable basket, recirculating pump, two (2) brass three-way directional valves for flow control. The components will be assembled and mounted on a Channel iron Base. Backwash control shall be automatic.

B. Unit shall be fully assembled, tested and adjusted at the manufacturer's plant. Unit shall be specifically designed for outdoor installation.

C. Components:

1. Vessel to be FRP fiberglass with a maximum pressure of 50 psi.
2. Pumps shall be bronze construction with semi-open face impeller to prevent clogging.
3. Pump pre-strainer to have removable ABS core and clear lid for easy inspection.
4. Internal components to be PVC. All pieces to be thread mounted for easy service.
5. Valves will be two (2) brass three-way ball valves with single lever linkage.
6. Media to be silica sand, all round grain.

D. Backwash Controls:

1. The unit quoted will be equipped with automatic controls.
2. NEMA 3R enclosures with the following:
   a. Access door with door interlock and manual push button.
   b. Manual motor starter with overload and short circuit protection.
   c. Motor relay for interface with building automation system.
   d. Pre-set timer for backwash.
   e. Transformer to convert line power to 110 volt control power.
3. Pre-set pressure switch to activate backwash function.
4. Motorized valve actuator to position flow valves for backwash.
5. Unit to be equipped and piped for backwash using city water.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conductivity Sensor: Mount in ½" line running between pump discharge and sump.

1. Provide ball valve upstream of sensor.

B. Pressure Switch: Mount in pump discharge line.

1. Wire to stop conductivity monitor and chemical pump when tower pump stops.

C. Bleed-Off Solenoid Valve: Mount in bleed-off line.

D. Bleed-Off Flow Rate Valve: Mount in bleed-off line.

E. Brominator Injection Assembly: Mount in sump.

F. Chemical Tubing: Enclose in EMT conduit.

G. Injection Assembly: Mount in return line.

3.2 MAKE-UP WATER SEQUENCE

A. Setup system to maintain a cycle of concentration of 2.5 (adj.).

B. Arrange chemical metering pump to operate when make-up solenoid opens.

1. Adjust flow to proper proportions based on flow.

3.3 START-UP PROCEDURES

A. During condenser cooling water system start-up, operate condenser water treating system (after charging with specified chemicals) to maintain the required steady-state characteristics of cooling water.

3.4 TESTING

A. Sample condenser cooling water at one-week intervals after condenser start-up for a period of four weeks.

1. Prepare certified test report for each required water performance characteristics.
   a. Comply with the following ASTM standards, where applicable:
      1) D 859 - Tests for Silica in Water and Waste Water.
      2) D 1067 - Tests for Acidity or Alkalinity of Water.
      3) D 1068 - Tests for Iron in Water and Waste Water.
      4) D 1126 - Tests for Hardness in Water.
      5) D 1128 - Identification of Types of Microorganisms and Microscopic Matter in Water and Waste Water.
      6) D 3370 - Sampling Water.

3.5 PERSONNEL TRAINING

A. Condenser Operator Training

1. Train Owner's personnel in use and operation of condenser water treatment system, including:
   a. Preparation of chemical solution, if applicable.
   b. Charging of the chemical solution reservoir.
2. Provide a minimum of 8 hours training.

3.6 ELECTRICAL

A. All control wiring or interlocks shall be provided by this division.

END OF SECTION 232516

SECTION 23 2600 - ENERGY METERING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. In addition to the work covered under this section, comply with description of individual systems under other sections of the Specifications.

PART 2 - PRODUCTS

2.1 BTU METERING STATIONS

A. Provide BTU demand and consumption metering stations where indicated on the drawings. Meters shall be of either natating disc, propeller type, turbine type, low pressure drop orifice type or sonic type. Meter shall be capable of accurate measurement while operating under design water flow turndown ratios as shown on the drawings or as specifically approved by the Architect. Provide meters with accessory 24 hour circular recorders with charts. Provide isolation shutoff values for maintenance purposes and line size spool pieces at metering.

B. Refer to detail drawings for metering arrangement.

C. Meter shall record peak demand in tons and consumption in ton-hours times 10 or other appropriate factor corresponding to the daily consumption at each meter.

D. Demand meters shall be capable of transmitting a remote signal to the Central Control and Monitoring system provided under the work of another Section for necessary control interface devices and equipment to achieve this function.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturers recommendations.

END OF SECTION 232600

SECTION 23 3113 - DUCTWORK

PART 1 - GENERAL

1.1 INDUSTRY STANDARDS

A. Construct ductwork to meet all functional criteria defined in Section 11 of the 2005. SMACNA "HVAC Duct Construction Standards, Metal and Flexible", Third Edition. Comply with SMACNA recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.

B. Comply with American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), except as otherwise indicated.

C. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.

1.2 SUBMITTALS

A. Detailed ductwork shop drawings, which include sizes, layouts, and pressure classifications, must be properly submitted. Any ductwork installed without prior written approval by the engineer of record shall be replaced at the expense of the contractor.

B. Shop Drawings: Submit shop drawings for:

1. Transition elbows.
2. Seal and reinforcing schedule for all ductwork fabrication types.
3. Turning vane and turning vane installation.

C. Product Data: Submit manufacturer's product data on the following:

1. Duct lining.
2. Duct lining adhesive.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. All interior ducts shall be constructed with G-90 or better galvanized steel (ASTM A653/653M) LFQ, chem treat. Exterior ductwork or duct exposed to high humidity conditions (i.e. kitchen exhausts) shall also be G-90 or better galvanized steel LFP, chem treat.

B. Aluminum duct shall be fabricated from lock forming grade, ally 3003-HI4, ASTM B209. Reinforcing angles, bars, tie rods, and other structural members shall be alloy 6061-T6. Hangers shall be 6061-T6 aluminum, or galvanized or painted steel with a dielectric isolation pad between the dissimilar metals.

C. Ungalvanized carbon steel shall be lockforming grade, hot rolled steel conforming to ASTM A366 or A619.

2.2 RECTANGULAR DUCT

A. Construct rectangular ductwork to meet all functional criteria defined in Section 11, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" 2005 Edition. All ductwork must comply with all local, state and federal code requirements.

B. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.

C. Pittsburgh lock shall be used on all longitudinal seams. All longitudinal seams will be sealed with mastic sealant. Snaplock is not acceptable.

D. Ductmate or W.D.C.I. proprietary duct connection systems will be accepted. Duct constructed using these systems will refer to the manufacturers guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcements.

E. Formed on flanges (T.D.C./T.D.F./T-25A/T-25B) shall be constructed as SMACNA T-25 flanges, whose limits are defined on Page 2.76 2005 SMACNA Manual, Third Edition. No other construction pertaining to formed on flanges, will be accepted. Formed on flanges shall be accepted for use on ductwork 42" wide or less, 2" static (positive) or less and must include the use of corners, bolts and cleat.

F. Ductmate type systems that use a butyl Rubber Gasket which meets Mil-C 18969B, Type II Class B, TT-C-1796 A, Type II Class B, and TTS-S-001657 must also pass UL-723. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth (as defined in 21CFR 177, 1210 closures with sealing gaskets for food containers).

G. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.

H. Fittings shall be constructed and reinforced as ductwork according to the longest span.

2.3 ROUND AND OVAL DUCT

A. Round and oval duct shall be galvanized steel, constructed in accordance with Section 11 of the 2005 SMACNA "Duct Construction Standards, Metal and Flexible", except as noted.

1. Lighter gauge factory made duct with an Intermediate standing rod may be used. Submit product data sustaining the equivalency of such duct into SMACNA standard duct.

B. Minimum duct gauge shall be 26 gauge.

C. Round ductwork shall be spiral lock seam construction only. Longitudinal seam duct is not acceptable. Gauges shall be in accordance with SMACNA Duct Construction Standard and fittings in accordance with SMACNA Duct Construction Standard, except as noted:

1. Joints 0”-20” diameter, interior slip coupling beaded at center, fastened to duct with sealing compound applied continuously around joint before assembling and after fastening. Wrap joints with 3-inch wide duct tape.
2. Joints 21”-72” diameter, use 3 piece, gasketed, flanged joints consisting of 2 internal flanges (with integral mastic sealant) split to accommodate minor differences in duct diameter, and one external closure band designed to compress gasketing between internal flanges. Example: Ductmate Spiralmate or equal.
3. Joints 73” diameter and up, use companion angle flanged joints only as defined on page 3-6 of the SMACNA Manual. Refer to manual for proper sizing and construction details. Ductwall to be welded longitudinal seams.

D. Fittings shall be continuously welded, standing seam, or spot welded and sealed. Metal thickness and reinforcing shall be equivalent to the requirements of the largest span.

1. All elbows greater than 45” shall be radius type, R=1.5 times duct diameter.
2. Elbows less than 6” shall be of die stamped construction. Elbows 6” or greater shall be 5-gore construction.
3. Diverging and converging flow fittings shall be constructed with no excess material projecting from the body into the branch tap entrance. All such fittings shall be 45° “shoe” entrance, wye plus elbow, or 45° lateral branch. Special fittings such as heel tapped elbows and bullhead tees may be used only where shown on drawings. Adjustable elbows and straight saddle taps shall not be used. Low pressure adjustable elbows acceptable.

2.4 VAPOR LADEN DUCT

A. Material: 22-gauge aluminum.

B. Seams: Seal all seams watertight.

C. Drainage: Run duct vertical or pitch toward hood.

2.5 CONTRACTOR FABRICATED CASINGS AND PLENUMS

A. Unless required otherwise by drawings, single wall casings and plenums may either be contractor or factory fabricated where shown on drawings. All double wall casings and plenums shall be factory fabricated.

B. Casings and plenums shall be constructed in accordance with the 2005 SMACNA “HVAC Duct Construction Standards,” Third Edition and as specified below.

C. All casings and plenums on the suction side of any fan, including return air outside air, or mixing plenum shall be constructed to 2” negative pressure class.

D. Louver blank-off panels shall be constructed to 2” negative pressure class.

E. All casings and plenums for relief and exhaust air shall be 2” positive or negative pressure class.

F. All casings and plenums on the discharge side of supply fans shall be 4” positive pressure class.

G. Single wall plenums shall be of the standing seam type construction. Submit shop drawings indicating overall dimensions, support details, corner and edge details, penetration details, equipment installation details, and pressure class.

H. Seal all seams, edges, and corners with approved duct sealant.

I. Casing materials shall be the same as that for the connected duct systems.

J. Where automatic dampers may, completely shut off air flow and subject plenum of casing to fan close off pressure, install pressure relief panels, rated to open at 125%.

2.6 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials and products of the types and sizes indicated, and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Double wall turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct. Tab spacing shall be SMACNA standard. Rail systems with non-standard tab spacings shall not be accepted. All tabs shall be used, do not skip tabs. Mounting rails shall have friction insert table, which align the vanes automatically. Vanes shall be subjected to tensile loading and be capable of supporting 250 lbs., when fastened per the manufacturer's instructions. Approved Systems: Ductmate PRO-Rail.

C. Single wall spliter and turning vanes shall be custom fabricated as specified below.

D. Ductwork Support Materials: Except as otherwise indicated, provide galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

E. Duct Liner:

1. Manufacturers:
   a. Design Basis: Johns-Manville
   b. Other Acceptable Manufacturers:
      1) Certainteed
      2) Owens Corning
      3) Knauf
2. Model: Minimum 1-1/2" Linacoustic RC with Permacoat (EPA registered antimicrobial coating), in accordance with UL 181, ASTM C1071, G21 and G22 with no observed growth.
3. Compliances:
   a. FSHH-1-545, Type I
   b. NFPA 90-A
4. Roughness: 0.0008 feet
5. Noise Reduction Coefficient: 0.85 or higher for 1-1/2" liner
6. Round Duct Liner: Spiracoustic "snap-in" type with Permacote.
7. Arena Bowl: Double-wall duct with 2" liner and perforated inner wall.

F. Duct Liner Adhesive:

1. Manufacturers:
   a. Design Basis: Childers
   b. Other Acceptable Manufacturers:
      1) King
      2) Hardcast
      3) Ductmate Industries, Inc., PROTack
2. Model:
   a. Indoor/Outdoor: CP-127 Chil-Quik

G. Duct Sealant:

1. Manufacturers:
   a. Design Basis: Ductmate PROseal
   b. Other Acceptable Manufacturers:
      1) United McGill Duct Sealer WB (Water Based)
      2) C.L. Ward SuperSeal
2. Model:
   a. Indoor: United Duct Sealer, PROseal
   b. Outdoor: Unicast, PROseal
3. Description: Non-hardening, liquid or mastic elastic sealant.
4. Fire Rating: UL 289U listed and NFC 220(b).
5. Sealants shall contain no VOCs.

H. Duct Tape Sealing System:

1. Manufacturers:
   a. Design Basis: Hardcast.
2. Model:
   a. Tape: DT
   b. Indoor Adhesive: FTA-20
   c. Outdoor Adhesive: RTA-50

I. Acoustical Duct Lagging:

1. Manufacturers:
   a. Design Basis: Sound Seal
   b. Other acceptable manufacturers:
      1) Kinetics Noise Control
      2) The Proudfoot Company
      3) Acoustical Solutions
   c. Model: B-10 LAG/QFA-3, foil face loaded vinyl or lead barrier sheet fully bonded to a minimum 1” thick fiberglass blanket, nominal density of 1.0psf, install so jacket edges overlap by minimum of 6”, minimum STC-27 tested by independent laboratory in accordance with ASTM E90 and E413, minimum insertion loss (IL) value at 500Hz shall be 23 and meets IMC flame/smoke ratings in accordance with ASTM E84.

J. Fiberglass ductboard is not accepted without prior written approval from the specifier.

K. Access doors shall be hinged or Ductmate Sandwich Type Access Doors manufactured by Ductmate Industries, Inc. Doors shall be of adequate size to allow easy access to hardware, which needs to be maintained.

L. Flexible Duct Connector:

1. Flexible duct connector shall be used where ductwork connects to fans of apparatus, or apparatus casing to fans.
2. Connectors will meet NFPA 90A and 90B specifications and provide an airtight and waterproof seal.
3. Indoor installations shall be Neoprene or vinyl coated fabrics.
4. Outdoor installations shall use Hypalon coated fabric.
5. Connector shall be Ductmate PROFlex or approved equal.

M. Roof Mounted Duct Supports

1. Description: The Contractor shall design and detail the self weight support of the roof-top HVAC ducts and their lateral stability to resist WIND and SEISMIC loads. The duct support design shall take into consideration the roof framing load carrying capacity for MEP systems supported above and below the roof and distribute the load effect so as not to overload the roof framing. The system shall consist of vertical hot dipped galvanized or stainless steel frame members or supports with welded 4”x4” base plate for permanent connection to the primary roof framing (not roof decking). The connection points of supports to the roof framing shall be provided with a “pitch pan” and shall be fabricated from the same material as the vertical support members. The “pitch pan” shall interface with roofing membrane, be filled with roofing asphalt, be flashed on all sides, and be provided with a water proof seal. Mechanical Contractor shall coordinate support system with Roofing Contractor and receive his approval. Provide shop drawings of system for review.

N. Provide seismic restraints as required for seismic zone. See 23 05 49.

2.7 FABRICATION

A. Construct rectangular ductwork to meet all functional criteria defined in Section VII, of the SMACNA “HVAC Duct Construction Standards Metal and Flexible” 2005 Edition. This shall be subsequently referred to as the SMACNA Manual. All ductwork must comply with all local, state and federal code requirements.

B. All “medium pressure” (systems with external pressures greater than 2” w.c.) duct systems shall be constructed for 4” W.C. positive and 1” W.C. negative static pressure and 3500 FPM velocity.

C. See air handler and fan schedules for external pressure requirements. All pressures above 2” E.S.P. shall be medium pressure.

D. All low pressure ductwork is to be constructed for 2” W.C. positive and 1” negative static pressure and 2000 FPM.

E. All negative pressure ductwork shall be constructed for a minimum of 2" W.C. negative and 2" W.C. positive static pressure and 2000 FPM velocity.

F. Make all changes in direction using 1.5 radius elbows where possible. Use splitter vanes or mitered rectangular elbows with turning vanes otherwise.

1. Use single thickness splitter vanes for all radius elbows less than 1.5 D = r.
   a. D = diameter of duct or width of duct (in plane of change-in-direction).
   b. r = radius of duct at duct center-line.
   c. Use "Curve Ratios" of 0.45 or greater (as defined by figure 3-7 of the 1989 ASHRAE Fundamentals Handbook).
2. Use single thickness turning vanes with no trailing edges in accordance with SMACNA Standards.
   a. All mitered, rectangular elbows in series.
   b. All mitered, rectangular elbows less than 36" in width (in plane of change-of-direction).
3. Use double width, airfoil type turning vanes with no trailing edges for all rectangular elbows greater than 36" in width (in plane of change-of-direction).
   a. Isolated elbows have a minimum of 3D straight duct upstream and downstream of the change-in-direction.

G. Fabricate transition elbows with turning vanes at correct angle so entering and leaving edges are parallel or tangent to air flow.

H. All branch duct take-offs shall use 45° laterals or 45° "pants-leg" type fittings.

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTWORK

A. Assemble and install ductwork in accordance with recognized industry practices, which will achieve air-tight and noiseless systems, capable of performing each indicated service.

B. Install each run with a minimum of joints.

C. Where ducts pass expansion joints or structural elements subject to movement provide flexible connections and supports to allow for movement without adverse effects.

D. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth.

E. Support ducts rigidly with suitable ties, braces, hangers and anchors of the type, which will hold ducts true-to-shape to prevent buckling. This Division is responsible for all duct supports.

F. Seal ducts in accordance with SMACNA requirements for pressure class indicated.

1. Indoor Ducts: Use liquid or mastic sealant, or tape system.
2. Outdoor Ducts: Use tape system.

3. Approved manufactured joining systems with gaskets may be used in lieu of transverse sealing.

G. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible.

H. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building.

1. Limit clearance to 0.5” where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
2. Where possible, locate insulated ductwork for 1.0” clearance outside of insulation.

I. In finished spaces, conceal ductwork by locating in mechanical shafts, hollow wall construction or above suspended ceilings.

J. Where possible, avoid locating ducts on or near floor.

1. Where ducts must be located low, provide metal trestle to protect duct at places where duct will be climbed over.

K. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work.

L. Install access doors where necessary for inspection and maintenance.

1. Provide additional 12” x 12” access door at each low leakage damper.
2. Arrange access doors so that:
   a. They open against the system air pressure wherever feasible.
   b. Their latches are operable from either side, except where the duct is too small to be entered.

M. Where ducts pass through non-fire-rated interior partitions below ceiling and exterior walls:

1. Conceal the space between the construction opening and the duct or duct-plus-insulation with sheet metal flanges of the same gauge as the duct.
2. Overlap the opening on all sides by at least 1-1½”.

N. Provide volume dampers at branch take-offs (except upstream of VAV boxes which should not have dampers).

O. Provide conical or tapered taps with balancing dampers on all round ductwork takeoffs (except upstream of VAV boxes, which should not have dampers).

P. Where space permits, round or oval ductwork of equivalent diameter may be substituted for unlined rectangular ductwork.

Q. Provide 22-gauge aluminum ductwork for the first 20 feet downstream of any aluminum grille. Slope duct towards grille at 1/8” /ft.

3.2 DUCT LINER INSTALLATION

A. Refer to Application Schedule, 23 07 00.

B. Ducts Exposed to Weather: Line all low velocity ducts exposed to weather with two inch thick lining.

1. Dimensions indicate free area.
2. Seal ducts to three-inch static pressure standards.
3. Paint exposed surfaces with aluminum asphalt roof paint.

C. Supply, return or outside air ductwork, which is not lined (as noted above) is to have exterior insulation. See Section 23 07 00 for insulation requirements on unlined ductwork.

1. Coordinate lined duct and insulated duct prior to bid.
2. Coordination of extent of liner or insulation, after bid award, shall be as directed by Engineer at no additional cost to Owner.

D. Seal all exposed ends of liner with duct liner adhesive back a minimum of 2" from ends. Seal all joints in liner a minimum of 1" overlap. Seal all fasteners.

E. Completely remove any loose material from each section of lined ductwork as it is installed.

F. Interrupt duct liner a minimum of 18" upstream and 30 inches downstream of all electric resistance heaters in duct system. If ductwork is used for cooling, wrap that portion of duct which is not lined and extend insulation a minimum of 12" beyond lining in each direction.

3.3 DUCT LEAKAGE TESTING

A. Installed ductwork shall be tested prior to installation of access doors, take-offs, etc.

B. All leak testing shall be witnessed by the Engineer or representative of the Engineer. The Contractor shall give the Engineer 72 hours notice prior to testing. Any testing not witnessed by the Engineer or his/her representative, shall be considered invalid and will be redone.

C. The testing shall be performed as follows:

1. Perform testing in accordance with HVAC Air Duct Leakage Test Manual.
2. Use a certified orifice tube for measuring the leakage.
3. Define section of system to be tested and blank off.
4. Determine the percentage of the system being tested.
5. Using the percentage, determine the allowable leakage (cfm) for that section being tested.
6. Pressurize to operating pressure and repair any significant or audible leaks.
7. Repressurize and measure leakage.
8. Repeat steps 6 and 7 until the leakage measured is less than the allowable defined in step 5.

D. All transverse joints and longitudinal seams shall conform to SMACNA's Class A sealing requirements as defined on page 1.17 of the 2005 SMACNA Manual, Third Edition.

E. Constant Volume Systems/Supply Ductwork
Allowable Leakage 1% of design cfm

F. Constant Volume Systems/Return Ductwork
Allowable Leakage 2% of design cfm

G. Variable Air Volume Systems/Supply Ductwork
Fan to VAV Boxes 1% of design cfm
VAV Boxes to Registers 2% of design cfm

H. Variable Air Volume Systems/Return Ductwork
Allowable Leakage 2% of design cfm

I. Exhaust Systems 1% of design cfm

J. Extent of Testing

1. Test the first 100' of each system listed above. If all systems pass, remaining ductwork will be permitted to be visually inspected. At Engineer's discretion, up to 5 additional tests at random system points may be required.
2. Refer to Section 23 09 03 for additional requirements.

3.4 DUCTWORK STORAGE AND CLEANING

A. Cleaning:

1. Interior surfaces shall be free of dust and debris prior to initial start up. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes. Any cleaning of duct systems shall comply with recommendations of NAIMA and NADCA.
2. When internally cleaning duct work prior to installation or shipment to the jobsite, all duct ends and openings must be covered prior to transporting with a dual Polyethylene protective film. Film must be securely affixed to protect against dirt and debris and must be translucent to facilitate inspection of interior surfaces without removing film. Film must have a minimum elongation of 600%, contain no VOC and leave no residue on duct after removal.
3. Clean external surfaces of foreign substances that might cause corrosion, deterioration of the metal, or where ductwork is to be painted.

B. Protection:

1. Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.
2. Cover all stored ducts to protect from moisture or debris.
3. Cover all ends of installed ductwork at the end of each workday or when dust and debris producing construction (such as fire proofing, drywall, sanding, or core drilling) is occurring.

C. Ductwork contaminated or damaged above “shop” or “mill” conditions shall be cleaned, repaired or replaced to the Engineer’s satisfaction.

1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.
2. Ductliner in installed ductwork, which has become wet must be completely removed and replaced.
3. Torn ductliner may be replaced by coating with adhesive if damaged is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

END OF SECTION 233113

SECTION 23 3117 - FABRIC DUCTWORK (Alternate 8)

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Extent of non-metal ductwork is indicated on drawings and by requirements of this section.

B. Types of non-metal ductwork required for this project include the following:

1. Fabric Air Dispersion Products.

1.2 QUALITY ASSURANCE

A. Building Codes and Standards:

1. Product must be Classified by Underwriter's Laboratories in accordance with the 25/50 flame spread / smoke developed requirements of NFPA 90-A and are also classified in accordance with ICC Evaluation Service AC167.
2. All product sections must be labeled with the logo and classification marking of Underwriter's Laboratories.

B. Design and Quality Control

1. Manufacturer must have documented design support information including duct sizing, vent and orifice location, vent and orifice sizing, length, and suspension. Parameters for design, including maximum air temperature, velocity, pressure and fabric permeability, shall be considered and documented.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's specifications on materials and manufactured products used for work of this section.

B. Building Code Data: Submit UL file number under which product is Classified by Underwriter's Laboratories.

1.4 WARRANTY

A. Manufacturer must provide a 5 Year Product Warranty for products supplied for the fabric portion of this system as well as a Design and Performance Warranty.

1.5 DELIVERY, STORAGE AND HANDLING

A. Protect fabric air dispersion systems from damage during shipping, storage and handling.

B. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURER

Subject to compliance with requirements, provide products manufactured in the United States, choose one of the following:

A. Basis of Design: KE Fibertec

B. DuctSox® Corporation

C. Approved equal.

2.2 FABRIC AIR DISPERSION SYSTEM

A. Verona Fabric: Air diffusers shall be constructed of a woven fire retardant fabric complying with the following physical characteristics:

1. Fabric Construction: 100% Flame Retardant
2. Weight: 5.2 oz. /yd2 per ASTM D3776
3. Color: (MUST SPECIFY- red, white, blue, green silver, tan or black)
4. Air Permeability: 2 (+2/-1) cfm/ft2 per ASTM D737, Frazier
5. Temperature Range: 0 degrees F to 180 degrees F
6. Fire Retardancy: Classified by Underwriters Laboratories in accordance with the requirements of NFPA 90-A and AC-167 (noted above).

B. SYSTEMS FABRICATION REQUIREMENTS:

1. Air dispersion accomplished by linear vent and permeable fabric. Linear vent is to consist of an array of open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents. Linear vents should also be designed to minimize dusting on fabric surface.
2. Size of and location of linear vents to be specified and approved by manufacturer.
3. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via zip screw fastener – supplied by contractor.
4. Inlet connection includes zipper for easy removal / maintenance.
5. Lengths to include required zippers as specified by manufacturer.
6. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.
7. Fabric system shall include connectors to accommodate suspension system listed below.
8. Any deviation from a straight run shall be made using a gored elbow or an efficiency tee. Normal 90 degree elbows are 5 gores and the radius of the elbow is 1.5 times the diameter of the DuctSox.

C. DESIGN PARAMETERS:

1. Fabric air diffusers shall be designed from 0.25” water gage minimum to 3.0” maximum, with 0.5” as the standard.
2. Fabric air diffusers shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).
3. Design CFM, static pressure and diffuser length shall be designed or approved by the manufacturer.
4. Do not use fabric diffusers in concealed locations.
5. Use fabric diffusers only for positive pressure air distribution components of the mechanical ventilation system.

D. SUSPENSION HARDWARE:

1. Tension Cable: System shall be installed using a tension cable system including double strands (2 Row) of cable located 3” above the 10 and 2 o’clock locations of the Fabric Duct system. Hardware to include cable, eye bolts, cable clamps and turnbuckle(s) as required. System attachment shall be made using nylon snap clips spaced 24 inches. Component options include (must specify per area if multiple on same project):
   a. Galvanized Steel Cable

PART 3 - INSTALLATION

3.1 INSTALLATION OF FABRIC AIR DISPERSION SYSTEM

A. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.

3.2 CLEANING AND PROTECTION

A. Clean air handling unit and ductwork prior to the Fabric Duct system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.

B. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.

C. If Fabric Duct systems become soiled during installation, they should be removed and cleaned following the manufacturers standard terms of laundry.

END OF SECTION 233117

SECTION 23 3300 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 INDUSTRY STANDARDS

A. Comply with SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) latest recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data on the following:

1. Flexible duct
2. Ceiling dampers
3. Fire dampers
4. Smoke dampers
5. Louvers
6. Louvered penthouses
7. Roof mounted intakes
8. Roof mounted reliefs
9. Gravity relief dampers
10. Sound attenuators

PART 2 - PRODUCTS

2.1 FLEXIBLE DUCT ACOUSTICAL

A. Manufacturers:

1. Flexmaster Type 1M.
2. ThermaFlex-MKE

B. Construction:

1. PE Liner film mechanically locked without adhesives.
2. Insulation: Minimum 1-½" thick fiberglass blanket with a polyethylene vapor barrier. Map 0.23 'c' factor, factory installed.
3. Helix: Corrosion resistant galvanized steel.

C. Pressure rating: 5" w.g. positive, 1" w.g. negative at maximum 180°F operating temperature.

D. Standards: NFPA90A UL-181, Class I, ASTM E-96 - Procedure A.

E. Insertion loss shall be at least:

	OCTAVE BAND (Hz)					
Duct Size	125	250	500	1000	2000	4000
8”	5.6	10.6	23.9	34.0	22.5	17.0
12”	6.6	27.8	22.8	29.0	18.7	10.9
	DB reduction for 6 foot length, straight route, 500 fpm.					

2.2 FLEXIBLE DUCT, HIGH PRESSURE

A. Manufacturers:

1. Design Basis: Flexmaster Type 3
2. Other Acceptable Manufacturers:
   a. Thermaflex, MKC
   b. Genflex, IGE
   c. American/Elgen

B. Construction:

1. Insulated: Reinforced inner liner, mechanically locked or bonded together by a corrosive resistant galvanized steel helix, Min. 1-½” thick fiberglass blanket with polyethylene vapor barrier. Max. 0.23 ‘c’ factor.
2. Uninsulated: Mechanically locked without adhesives with a corrosion resistant galvanized steel helix.
3. Aluminum: Mechanical lock without adhesives.

C. Pressure rating: 12” w.g. positive, 1” w.g. negative at 180^0F.

D. Standards: NFPA90A, UL-181 Class I, ASTM E96 - Procedure A.

2.3 LOUVERS

A. Louvers are specified in the Architectural Division. This division is responsible for coordinating all duct connections, damper sizes, etc. with the louvers specified.

2.4 INTAKE PENTHOUSES

A. Manufacturers:

1. Design Basis: American Warming.
2. Other Acceptable Manufacturers:
   a. Commercial Acoustics
   b. Penn

B. Construction: 12 gauge aluminum, braced for 30 psf wind load. Structural support and flashing for installation on roof curb.

2.5 PREFABRICATED CURBS

A. General: Except where curbs are provided with equipment, provide prefabricated curbs for all roof mounted equipment.

B. Manufacturers:

1. Design Basis: Pace
2. Other Acceptable Manufacturers:
   a. Thycurb

C. Model for grease-laden exhaust fans: ES-2.

1. Coordinate to fit vibration isolation rail.

D. Coordinate with roofing Contractor. Exterior insulation, cants, flashing and counter flashing shall be furnished and installed under roofing work, Division 7.

E. Model: As required.

2.6 SOUND ATTENUATORS

A. Manufacturers:

1. Design Basis: Commercial Acoustics
2. Other Acceptable Manufacturers:
   a. Acoustifoil
   b. Aerosonics
   c. American Air Filter
   d. Commercial Acoustics
   e. Gale
   f. Industrial Acoustics
   g. Kinetics
   h. Rink
   i. Semco
   j. Transonics
   k. United Sheetmetal
   l. Vibro Acoustics

B. Acoustical Performance

1. All duct silencer performance data shall be derived from National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory tests in accordance with ASTM E477-99, Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers. Submit certification of acoustical and aerodynamic performance.

2.7 INTAKES AND RELIEF VENTS

A. Manufacturers:

1. Design Basis: Loren Cook

2. Other Acceptable Manufacturers:
    a. Carnes
    b. Commercial Acoustics
    c. Creative Metals
    d. Greenheck
    e. Jenn Air
    f. Acme
    g. Penn
    h. Powerline

B. Construction: Aluminum panels, bird screen.

C. Pressure Drop: .05" at 500 fpm throat velocity.

2.8 GRAVITY RELIEF DAMPERS

A. Manufacturers:

1. Design Basis: Air Balance.

B. Model: 702H.

C. Construction: Nylon bearings, felt weather-stripping, steel frames, and aluminum blades.

D. Pressure Drop: .018" at 500 fpm.

2.9 FIRE DAMPERS

A. Manufacturers:

1. Design Basis: Ruskin
2. Other Acceptable Manufacturers:
    a. Air Balance
    b. Prefco
    c. Safe-Air
    d. United Air
    e. United Sheetmetal
    f. National Controlled Air
    g. Air Control Products
    h. Greenheck
    i. Pottorff
    j. Nailor

B. Rating: UL555 dynamic 1-½ hours, or 3 hours, UL555S Class II leakage rated. Match construction penetrated.

C. Size: Metal-to-metal for lined and unlined ducts.

D. For curtain type, use Type B "Top Hat" wherever possible.

E. Integral factory mounted access door.

2.10 FIRE/SMOKE DAMPERS

A. Manufacturers:

1. Design Basis: Ruskin
2. Other Acceptable Manufacturers:
   a. National Controlled Air
   b. Johnson Controls
   c. Safe Air
   d. Prefco
   e. Air Balance
   f. Greenheck
   g. Pottorff
   h. Nailor

B. Fire Damper Rating: UL Standard 555 Dynamic, 1-½ hour or 3 hours.

C. Smoke Damper Rating: UL Standard 555S, Class II.

D. Damper Assembly:

1. Type: 120 volt.
2. Listing: UL 555S, UL555.
3. Rating: Match wall rating.
4. Failure Position: Fail closed.
5. Heat Sensor: 165°F fusible link.
6. Blade: Air foil.
7. Seals: Mechanically fastened, rated up to 450°F.
8. Integral factory mounted access door.

E. Where part of Smoke Control System.

1. Provide end switch for positive indication of damper position.
2. Provide means to re-open damper remotely in the event thermal link trips. Allow for re-open up to elevated rating of 250°F.

2.11 SMOKE DAMPERS

A. Manufacturers:

1. Design Basis: Prefco
2. Other Acceptable Manufacturers:
   a. Air Balance
   b. Greenheck
   c. Johnson Controls
   d. National Controlled Air
   e. Pottorff
   f. Ruskin

g. Safe Air
h. Nailor

B. Smoke Damper Rating: UL Standard 555S, Class II.

C. Operator:

1. Type: 120 volt.
2. Listing: UL Smoke Damper Operator Label.
3. Failure Position:
   a. Smoke control system dampers: As shown on plans.
   b. Others: Closed
4. UL listed modulating actuator at dampers that are part of smoke control system.

D. Blade: Air foil.

E. Seals: Steel.

F. Integral factory mounted access door.

G. Where part of smoke control system:

1. Provide end switch for positive indication of damper position.

2.12 CEILING DAMPERS

A. Manufacturers:

1. Design Basis: Airstream Products Div. Of Penn Ventilator Company.
2. Other Acceptable Manufacturers:
   a. Air Balance
   b. J & J
   c. Pottorff
   d. Prefco
   e. Ruskin
   f. Safe Air
   g. Nailor

B. Model: Duct Defender.

C. Rating: UL one hour.

D. Location: Air distribution penetrations in rated ceilings.

2.13 MISCELLANEOUS DUCTWORK ACCESSORIES

A. Duct Access Doors: Provide duct access doors with gaskets, and with insulation where ductwork is indicated to be insulated.

1. Manufacturer:

a. Design Basis: Cesco
b. Model: HAD hinged

2. Other acceptable manufacturers:
a. Flexmaster
b. Milcor
c. Elmdor

B. Flexible Connectors: Fireproof glass cloth, Vent-Fab or approved equal.

1. Manufacturers:
a. Design Basis: Vent-Fab
b. Other Acceptable Manufacturers:
1) Duro-Dyne
2. Material: Fireproof glass cloth

2.14 BACKDRAFT DAMPERS

A. Construction:

1. Frame: Extruded aluminum.
2. Blades: Formed aluminum with extruded vinyl edge seals.
3. Bearings: Synthetic

B. Performance: 12 cfm per square foot at ½" W.G.

2.15 BALANCING DAMPERS

A. Construction:

1. Frame: 16 gauge galvanized steel.
2. Blades: 16 gauge galvanized steel with vinyl edge seals.
3. Bearings: Heavy duty nylon.
4. Performance:
a. Maximum pressure drop in full open position (@3000 fpm): 0.55
b. Maximum leakage: 32 cfm/sp at 4" W.C.

B. Type: Rectangular balancing dampers are to be opposed blade type with locking handle, unless otherwise noted.

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESSORIES

A. Install fire, smoke and ceiling dampers in accordance with manufacturer's instructions and the latest version of the Fire, Smoke and Radiation Damper Guide for HVAC Systems, published by SMACNA.

B. Install access doors where necessary for inspection and maintenance.

1. Provide additional 12” x 12” access door at each low leakage damper.
2. Arrange access doors so that:
    a. They open against the system air pressure, wherever feasible.
    b. Their latches are operable from either side, except where the duct is too small to be entered.
    c. Install flexible connectors at all duct connections to rotating or reciprocating machinery or equipment.
3. Provide access doors at all fire damper locations.

C. Use HIGH PRESSURE flexible duct where shown upstream of VAV boxes.

D. Notify fire alarm provider of smoke damper control requirements and fire alarm interlocks.

E. Install flexible ductwork without tight bends and free of kinks.

1. Flexible ductwork shall not be less than 4’, nor exceed 8’ in length.
2. Flexible ductwork shall be installed with a “minimum length of straight duct” upstream of the diffuser neck inlet. “A minimum length” shall mean a length equal to three (3) duct diameters. “Straight duct” shall mean the center-line of the duct shall be aligned with a line perpendicular to the plane of the diffuser neck opening at the center point of the opening.
3. Conform to the detail on the drawings.

F. Install all dampers, including those furnished by Section 23 09 00 Contractor.

1. Caulk damper frames to ductwork.
2. Make sure dampers are free to operate properly.
3. Install parallel blade mixing dampers to two streams impinge on each other to facilitate mixing.

G. Provide balance dampers at branch take-off and where required to minimize balancing performed at diffuser face.

H. Provide all balance dampers as shown on plans and any additional dampers necessary to provide a balanced system meeting all sound requirements.

END OF SECTION 233300

SECTION 23 3400 - FANS

PART 1 - GENERAL

1.1 QUALITY CONTROL

A. Provide fans with AMCA performance certification and label.

1.2 MOTOR HORSEPOWER

A. Do not increase or decrease motor horsepower from that specified without written approval from Architect/Engineer. See Section 23 05 01.

1.3 SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's product data including:

1. Performance
2. Size
3. Type
4. Options provided
5. Fan curves
6. Indicate Compliance with Section 1.1 where applicable.

PART 2 - PRODUCTS

2.1 WALL EXHAUSTERS, CENTRIFUGAL

A. Manufacturers:

1. Design Basis: Cook
2. Other Acceptable Manufacturers:
    a. Aerovent
    b. Ammerman
    c. Carnes
    d. Acme
    e. Greenheck
    f. Hurricane
    g. Jenn Air
    h. Penn
    i. Powerline
    j. Ilg

B. Features:

1. Spun aluminum housing.
2. Internal rubber vibration isolators.

3. Ball bearings.

C. General:

1. Provide:
   a. Bird screen.
   b. Gravity back-draft damper:
      1) 0.2 inches WC max. pd.
2. Provide motorized type back-draft damper where indicated.

2.2 POWER ROOF VENTILATORS, CENTRIFUGAL

A. Manufacturers:

1. Design Basis: Cook
2. Other Acceptable Manufacturers:
   a. Aerovent
   b. Ammerman
   c. Carnes
   d. Acme
   e. Greenheck
   f. Hurricane
   g. Jenn Air
   h. Penn
   i. Powerline
   j. Ilg

B. Features:

1. Spun aluminum housing.
2. Internal rubber vibration isolators.
3. Ball bearings.

C. General:

1. Provide:
   a. Bird screen.
   b. Gravity back-draft damper:
      1) 0.2 inches WC max. pd.
   c. Motorized type backdraft damper where indicated.

D. Roof Curb:

1. Curbs will be provided under another Division.
2. Provide dimension data to Supplier of roof curbs.
3. Provide factory fabricated roof curb of height required by local authorities.

E. Sound Criteria:

1. Required sound levels may be attained by use of sound attenuating curbs.

2. Fan shall have specified capacity with curb in place.
3. Curb pressure drop is not included in specified ratings.

2.3 UP-BLAST ROOF EXHAUSTER

A. Manufacturers:

1. Design Basis: Acme
2. Other Acceptable Manufacturers:
   a. Ammerman
   b. Carnes
   c. Cook
   d. Greenheck
   e. Hurricane
   f. Jenn Air
   g. Penn
   h. Powerline

B. Features:

1. Spun aluminum housing.
2. Outside air motor cooling.
3. Grease trough.
4. Internal rubber vibration eliminators.
5. UL listed for grease laden air where noted on drawings.

C. Accessories:

1. Bird screen.

D. Provide factory fabricated curb of height required by local code.

PART 3 - EXECUTION

3.1 NOISE AND VIBRATION

A. Insure that fans are properly supported on vibration isolators. Reference Section 23 05 48 for Vibration Isolation Requirements.

B. Insure that flexible duct connections are properly made.

C. Check fan for improper balance.

1. Have fan re-balanced if necessary.

D. Check for proper rotation.

E. Check for unusual noise or vibration and correct as necessary.

3.2 ACCESS

A. Provide for proper access to all parts of fan needing inspection or service with access doors in fan or ductwork.

3.3 INSTALLATION

A. Install units level and plumb.

B. Provide necessary auxiliary supporting steel.

C. Mount motor and drives so belts run true.

D. Provide necessary lubrication.

E. Provide flexible duct connections on inlet and discharge.

3.4 CURBS

A. Provide necessary dimensions and details so roof opening can be provided at the proper time.

B. Coordinate delivery of curb with roofing contractor so project is not delayed.

C. Provide a weatherproof installation:

1. Seal all joints including, but not limited to:
   a. Unit and curb.
   b. Unit and ducts.

END OF SECTION 233400

SECTION 23 3600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable volume terminal units.

B. Variable volume regulators.

C. Integral heating coils.

D. Integral damper motor operators.

E. Integral controls.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 09 00 - Controls and Instrumentation: Thermostats and control components.

1.3 REFERENCES

A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

B. UL 181 - Factory-Made Air Ducts and Connectors.

C. ARI 880 - Air Conditioning and Refrigeration Institute Standard Rating Conditions for Air Terminals.

D. UL - Shutoff terminal must be UL listed as a Room Air Terminal.

E. ASTM A 527 (Steel Sheet, Zinc Coated Galvanized)

1.4 SUBMITTALS

A. Submit shop drawings and product data sheets indicating configuration, general assembly, and materials used in fabrication.

B. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, and radiated sound power levels (2nd through 7th octave bands) at design maximum operating conditions. Also submit Radiated Sound NC values. Shall be calculated at design conditions with the following path attenuation credits:

CORRECTION TO OCTAVE BAND SOUND POWER VALUE	2	3	4	5	6	7
Env Adj	-3	-2	-1	-1-	-1	-1
Mineral Fiber Ceiling Tile	-9	-10	-12	-14	-15	-15

CORRECTION TO OCTAVE BAND SOUND POWER VALUE	2	3	4	5	6	7
Space Effect Factor	-10	-11	-12	-13	-13	-14

This transfer function represents modeling assumptions based on ARI 885-90.

C. Submit manufacturer's installation instructions.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum ten years experience.

1.6 WARRANTY

A. Provide one year manufacturer's parts warranty.

PART 2 - PRODUCTS

2.1 SINGLE DUCT VAV BOXES

A. Manufacturers:

1. Trane
2. Metal Aire
3. Enviro-Tec
4. Titus
5. Johnson Controls
6. Nailor
7. Price
8. Krueger
9. Siemens

B. Sound Criteria:

1. Conform to ARI 880 performance test standard.
2. Discharge Sound:
   a. 0.2" SP: NC40
   b. 1.0" SP: NC53
3. Radiated Sound:
   a. 0.2" SP: NC27
   b. 1.0" SP: NC41
4. Sound levels may be attained using attenuators, but pressure drop of attenuator must be included as part of unit pressure drop.
   a. Units will discharge into lined or fiberglass ductwork, credit for which cannot be claimed in sound criteria.

C. Duct Connections:

1. Duct connections shown on drawing are minimum.
2. Units with larger connections may be used to meet pressure or sound requirements.
3. Flexible duct shall be same size as unit connection.

D. Construction:

1. Galvanized steel, one inch lining, conforming to UL181 and NFPA90A.
2. Maximum leakage not exceeding 1% design flow.

E. Heating Coils:

1. Refer to Section 23 82 16 coils.

F. Control:

1. Electronic, using velocity sensor, with compensation or correction for distorted flow at inlet.
2. Maximum and minimum volume controls shall be:
   a. Factory set (with allowance for altitude of project).
   b. Accurate within 10%.
3. Units shall be normally open with reversing relay for use with direct acting thermostat.
4. Provide electric motor.
5. Coordinate spring range with Automatic Temperature Control Section.
6. Coordinate controls on VAV units with control contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION 233600

SECTION 23 3700 - AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 CEILING CONSTRUCTION

A. Provide products compatible with ceiling construction.

1.2 SUBMITTALS

A. Submit catalog data including throw, sound, pressure drop and physical dimensions.

1.3 INDUSTRY STANDARDS

A. Provide products tested in accordance with ASHRAE 70-1991 150 Standard 5219, 150 Standard 3741.

PART 2 - PRODUCTS

2.1 GRILLES AND RECTANGULAR DIFFUSERS

A. Manufacturers:

1. Titus
2. Krueger
3. Metal Aire
4. Nailor
5. Price

B. Material: Steel or aluminum except:

1. Where noted otherwise.
2. Where required otherwise for fire rating.
3. Grilles and diffusers in locker rooms, showers and toilet rooms in locker rooms to be aluminum.

C. Finish: Baked white enamel except where noted.

D. Refer to the Drawings for required performance.

E. Match frame and border types to ceiling system.

2.2 SLOT DIFFUSERS WITH FACTORY-SUPPLIED PLENUMS

A. Manufacturers:

1. Titus

2. Metal Aire
3. Kruger
4. Nailor
5. Price

B. Material: Steel or aluminum except:

1. Where noted otherwise.
2. Required otherwise for fire rating.

C. Finish: Baked white enamel except where noted.

D. Inlet Size: Match duct size.

E. Match frame and border types to ceiling system.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to architectural reflected ceiling plan for exact locations and ceiling types.

B. Provide all support and framing devices necessary.

C. Exposed mounting screws:

1. Use tamper proof screws in countersunk holes.
2. Point screws to match frame.

D. Fire Rated Ceilings:

1. Provide insulation equivalent to ceiling construction above diffuser between ceiling opening and ceiling damper.

E. Install security type devices in accordance with manufacturer’s directions.

F. Verify diffuser face orientation and blade angles for seating bowl and other restricted access locations with balancing contractor and engineer prior to installation and balancing.

END OF SECTION 233700

SECTION 23 4000 - AIR CLEANING

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data including:

1. Media:
   a. Description
   b. Efficiency
   c. Test method
2. Enclosure
3. Support requirements
4. Weight
5. Electrical data
6. Drawings showing dimensions

1.2 QUALITY CONTROL

A. All filters shall be listed as class II per UL Standard 900.

PART 2 - PRODUCTS

2.1 TYPE A FILTERS

A. Manufacturers:

1. Design Basis: Farr
2. Other Acceptable Manufacturers:
   a. American Air Filter
   b. Air Guard
   c. Cambridge
   d. Eco Air
3. Model: 1" Aeropleat IV

B. Media and Performance:

1. Non woven cotton/synthetic.
2. Average 20% efficiency. 85% arrestance per ASHRAE 52-76.
3. Not less than 2.3 square feet of media per square foot of face area.
4. Not more than .16" WG initial resistance at 375 FPM.
5. Capable of .90" WG final resistance.

C. Support

1. Wire grid media support to maintain radial pleats.

2. Beverage board frame and diagonal supports.

2.2 TYPE B FILTERS

A. Maintenance:

1. Design basis Farr.
2. Other acceptable manufacturers.
   a. American Air Filters
   b. Air Guard
   c. Cambridge
   d. ECO Air
3. Model: 2” 30/30

B. Media and Performance:

1. Non-woven cotton/synthetic
2. Average 30% efficiency. 90% arrestance per ASHRAE 52.1-92.
3. Clean filter efficiency of 23% at one micron.
4. Not less than 4.6 square feet of media area per square foot of filter area.
5. No more than .13” WG initial resistance at 375 FPM.
6. Capable of .90” final resistance.

C. Support

1. Welded wire grid to maintain radial pleats.
2. Beverage board frame and diagonal supports.

2.3 TYPE C FILTERS

A. Manufacturers:

1. Basis of design: Farr.
2. other acceptable Manufacturers:
   a. American Air Filter
   b. Cambridge
   c. Environmental Air Filter
   d. Eco Air
3. Model: 12” Riga-Flo 200.

B. Media and Performance:

1. High density micro fine glass fiber.
2. Average 90% efficiency, 99% arrestance per ASHRAE 52.1-92.
3. Clean filter efficiency of 97% at one micron.
4. 200 grams dust holding capacity at 1.0” SP 300 FPM.
5. Not more than .35” S.P. initial resistance at 300 FPM.
6. Capable of 1.5” S.P. final resistance.

C. Support

1. Rigid cartridge type.
2. Welded wire grid to maintain pleat shape.
3. Contour stabilizers to maintain pleat spacing.
4. Galvanized steel enclosure and diagonal supports.
5. Capable of withstanding 10” S.P. drop without noticeable distortion.

2.4 SIDE ACCESS FILTER HOUSING

A. Manufacturers:

1. Design basis: Farr
2. Model: P Glide Pack

B. Features:

1. 2” track for pre filter.
2. Track to hold universal holding frame with seal.
3. Universal holding frame with full gaskets on inside face and sides to hold any standard size final filter.
4. Access doors on both sides with closed cell neoprene gaskets, and adjustable latches.
5. Pressure taps to sense pressure drop of pre filter, final filter, or both.

C. Performance:

1. Leakage, upstream of filter to downstream of filter: Not more than 1% of rated airflow (at 500 FPM) at 3” S.P.
2. Leakage into housing from ambient atmosphere: Less than 0.5% of rated airflow (at 500 FPM) at 3” negative S.P.

2.5 BUILT UP/REAR ACCESS HOLDING FRAMES

A. Manufacturers:

1. Design basis: Farr
2. Model: Type 8

B. Features:

1. 16 gauge galvanized steel
2. Filter centering means
3. Foam gaskets
4. Spring type filter fasteners.

2.6 FILTER GAUGES

A. Dwyer Mangehelic Series 2000.

B. Provide mounting bracket, tubing, static pressure tips and vent valves.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate filter banks to allow for access and prevent interference or damage by other components such as dampers and humidifiers.

B. Provide vertical and horizontal stiffening bars, blank offs, angle flashing as necessary to install built up filter banks in plenum. Gasket or caulk between frame members, flashings, and blank offs.

C. Provide filter gauges to measure pressure drop of all filter banks with Type B or C filters.

D. Electric filters shall be installed at the air handler manufacturers factory and field tested by the filter manufacturer. Filter manufacturer shall provide start up for the filters.

E. Contractor shall provide a filter replacement matrix schedule for each unit indicating size and filter type.

F. Provide and install a clean set of filters in all equipment prior to turn over to owner and one spare filter for each unit. For units with multiple filters provide a spare filter for each type.

END OF SECTION 234000

SECTION 23 5100 - FLUE SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract, Division 1 Specification Sections (General Requirements), apply to this section.

1.2 SUBMITTALS

A. Submit manufacturer's product data on:

1. Double wall vent pipe specifications.
2. Engineered, factory provided drawing of intended design and routing including all components and sizes.
    a. Submit pressure drop calculation.

PART 2 - PRODUCTS

2.1 DOUBLE WALL GAS VENT

A. Manufacturers:

1. Design Basis: Selkirk Metalbestos
2. Other Acceptable Manufacturers:
    a. Metal-Fab, Inc.
    b. Hart and Cooley
    c. Ampco

2.2 CONDENSING FLUE GAS

A. Manufacturers:

1. Design Basis: Heat-Fab Inc.

B. Model: Saf-T CI Vent

C. Type: AL 29-4C

1. Material:
    a. Outer Wall: 430 Stainless steel.
    b. Insulation: 5/32" air space.
    c. Inner Wall: AL 29-4C Stainless steel alloy.
    d. Pressure: Positive up to 3" wc, negative or neutral.
2. Self supporting, with proper support fitting, to 10' above a roof.

3. UL listed for intended use and UL listed per UL1738.

PART 3 - EXECUTION

3.1 GENERAL

A. Make all vent pipe from draft hood or appliance connection to vent cap double wall.

B. Fittings:

1. Use factory-made fittings for all changes in direction and connections, and for support and flashing.

C. Accessories: Provide necessary:

1. Thimbles
2. Flashings
3. Caps
4. Support assemblies
5. Elbows
6. Tee
7. Accessories recommended by manufacturer for complete installation.

D. Use Type AL29-4C for any boiler or water heater requiring Class II or IV vent (condensing type equipment).

E. Provide barometric dampers in accordance with manufacturers guidelines for all water heaters and boilers.

END OF SECTION 235100

SECTION 23 5200 - BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract, and Division 1 Specification Sections (General Requirements), apply to this Section.

1.2 REFERENCES

A. ASME Section IV

B. CAN-1.3.1-77, Industrial and Commercial Gas Fired Packaged Boilers

C. CSD-1, Controls and Safety Devices

D. GE GAP

E. NEC, National Electric Code

F. UL-795 7th Edition

G. AHRI, BTS-2000

1.3 QUALITY ASSURANCE

A. ASME Code Symbol Stamps: Provide boilers and safety (pressure relief) valves complying with ASME Code and stamped with appropriate code symbols.

B. Hydronics Institute Insignia: Provide cast-iron boilers, which have been I-B-R (Institute of Boiler and Radiator Manufacturers) performance rated and have affixed the I-B-R insignia of the Hydronics Institute.

C. AGA Certification: Provide boiler of design certified by American Gas Association.

D. Submittals:

1. Product Data: Submit manufacturer’s technical product data, including rated capacities of selected model, weights (shipping, installed and operating), installation and start-up instructions, and furnished accessory information.
2. Shop Drawings: Submit manufacturer’s end assembly drawings indicating dimensions, connection locations, and clearance requirements.
3. Wiring Diagrams: Submit manufacturer’s electrical requirements for the boiler including ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

E. The burner and controls shall conform to the requirements of Industrial Risk Insurers (IRI), and Factory Mutual (FM).

F. General Requirements for Boiler Suppliers:

1. The Boiler Representative shall be an authorized representative of the Boiler manufacturer and shall have been actively engaged with this manufacturer and in this field of operation for not less than five years. The installing contractor or boiler supplier shall have a service department as a permanent and integral part of his company with 24-hour service available at all times. The contractor or boiler supplier's stocking warehouse shall be no more than 100 miles from the jobsite and stock standard replacement parts for the boiler.
2. The entity responsible for boiler service during the warranty period and his 24 hour service phone number shall be specified in the O & M manual.
3. The boiler representative shall provide a factory trained and factory authorized representative to perform the following:
    a. Verify proper installation of boiler.
    b. Verify installation of boiler gas train.
    c. Verify proper wiring of controls and for proper operation of the controls in accordance with the boiler listing, manufacturer's directions and Sequence of Operation given in Section 23 09 00.
    d. Adjust firing and perform combustion test. Testing shall be performed at full load conditions. The equipment and instruments required to perform the tests must meet with the approval of the Engineer.
    e. The above tests must be certified by the factory authorized representative performing the test.
    f. Provide free inspection and adjustment of the burner installation for the full warranty period of the installation.
    g. Adjust power burners to provide sea level output at the jobsite elevation.

G. The boiler shall have an ASME Section IV pressure vessel rated for a maximum allowable working pressure of 160 PSIG and a maximum allowable working temperature of 210°F.

H. The flame safeguard control on the boiler shall be integrated with temperature control functionality.

I. The entire boiler system and its installation shall conform to the manufacturer's instructions, applicable codes and associated National Board requirements.

J. The equipment shall be in strict compliance with the requirements of this specification and shall be the manufacturer's standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which are not specifically identified but which are a part of the manufacturer's standard commercial product, shall be included in the equipment being furnished.

1. Standard items to be included with every boiler:
    a. Low water cut off probe installed in the pressure vessel
    b. High and low gas pressure switches
    c. Lockup style regulator mounted within the boiler cabinet
    d. Combustion air inlet filter

K. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer's current catalog.

L. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.

M. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.

N. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.

O. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.

1.4 REGULATORY REQUIREMENTS

A. Comply with the requirements of all authorities having jurisdiction including but not limited to:

1. State Boiler Inspector.
2. Local Building Department.
3. Owner's Insurance Carrier.

B. Provide all gas train components, operating controls, safety controls, low water cut outs, and other components required for the occupancy of the building and the size of the boiler.

PART 2 - PRODUCTS

2.1 CONDENSING BOILER

A. Manufacturers

1. Basis of Design: Fulton Endura
2. Other acceptable manufacturers:
   a. Manufacturers that meet these specifications.

2.2 BOILER CONSTRUCTION

A. The boiler shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping.

B. The pressure vessel design and construction shall be in accordance with Section IV of the ASME Code for heating boilers. The boiler shall comply with CSD-1 code requirements.

C. The pressure vessel shell shall be a minimum 5/16" thick steel, SA-790 or SA-516 Grade 70 plate.

D. Tube sheets should be designed with low weld intensity with a tube to tube minimum spacing of 2" center to center and minimum 5/8" tube to tube ligament.

E. The firetube area of the heat exchanger where the flue gases will condense shall be constructed using duplex alloys of stainless steel.

F. Heat exchange capability shall be maximized within the pressure vessel via the use of corrulator fire tube technology. All heat transfer enhancements shall be stainless steel.

G. The boiler shall be a fire tube design. The furnace location shall be such that all furnace components are within water-backed areas.

2.3 BOILER DESIGN

A. External convection and radiation heat losses to the boiler room from the boiler shall be less than 0.2% of the rated boiler input.

B. The boiler shall have its efficiency witnessed and certified by an independent third party, and the efficiency must be listed on the AHRI directory (www.ahridirectory.org) for natural gas operation. The test parameters for efficiency certification shall be the BTS-2000 standard, with 80°F return water temperature, 180°F supply water temperature, steady state operation at full input firing capacity.

C. The boiler shall have no minimum return water temperature requirements.

D. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. Flow switches, dedicated circulator pumps, or primary/secondary piping arrangements are not required to protect the heat exchanger or pressure vessel from thermal shock or other system related considerations.

E. The boiler shall have a pre-mix combustion system, capable of operating at a minimum 4” W.C. incoming natural gas pressure while simultaneously achieving emissions performance, full modulation, and full rated input capacity. Maximum natural gas pressure allowed to the inlet of the fuel train shall be no less than 28” W.C.

F. The exhaust manifold shall be constructed of stainless steel, with a collection area for the ultimate disposal of flue gas condensate. The boiler exhaust connection shall allow for immediate vertical rise off the boiler without the use of an elbow or tee.

2.4 VENTING

A. The boiler shall be capable of operating with a natural draft not exceeding -0.04” W.C. and a combined air intake and exhaust venting pressure drop not exceeding +1.50” W.C.

B. It shall be acceptable to either direct vent the boiler using sealed combustion by drawing in combustion air from the outdoors or by drawing air from the mechanical space itself.

1. Combustion air supply from the outdoors piped directly to the air inlet of the boiler: Intake piping shall be Schedule 40 PVC, galvanized or stainless steel, or equivalent.
2. Combustion air supply from the mechanical space: Adequate combustion air and ventilation shall be supplied to the boiler room in accordance with local codes.

C. The flue gas exhaust stack shall be AL 29-4C or 316L stainless steel, listed and labeled to UL-1738 / C-UL S636 for use with Category II/IV appliances, guaranteed appropriate for the application by the manufacturer and supplier of the venting.

D. The boiler shall be capable of common exhaust and intake venting. The draft system shall be designed to prevent backflow of exhaust gases through idle boilers.

2.5 CONTROLS

A. The boiler control panel shall be constructed in a UL 508 approved panel shop.

B. Ignition shall be via direct spark. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer.

C. The boiler shall operate at no greater than 7.0% excess O2 over the entire turndown range to maximize seasonal combustion and thermal efficiencies.

1. The boiler shall be preconfigured by the manufacturer with a default setting of 5:1 turndown. Wind and draft effects on combustion air supply and exhaust systems, fuel delivery components, among other site factors, will ultimately determine the optimal O2, minimum input, and maximum input settings for the installation.

D. The boiler shall maintain a NOx level of <20 ppm at a 3% O2 correction for all operating conditions when firing on standard natural gas.

E. For an individual boiler, the integrated control shall provide boiler status, configuration, history and diagnostics:

1. Flame programming/flame safeguard control
2. Temperature (PID) load control capability for up to two loops (central heat and/or domestic hot water).
3. Color touch screen display with screen saver, screen disable for cleaning, contrast control and volume control for alarm features
4. ModBus communication capabilities
    a. BacNet communication available with a gateway (optional)
5. Time of day display
6. Enable/disable control of up to three (3) devices (pumps, valves, etc.) with programmable time delay for disable of the device(s)
7. Customizable boiler name display
8. Display fifteen (15) most recent alarms including equipment status at time of lockout
9. Ability to accept a remote 4-20mA signal for setpoint or firing rate
10. Password protect options
11. Outdoor reset capabilities for an individual boiler with warm weather shutdown

F. Each individual boiler shall be able to be set up appropriately with programmable limits displayed on the boiler touchscreen interface:

1. Outlet water temperature
    a. Parameters within the control will be used to manage boiler operating temperatures and turndown to adhere with published manufacturer guidelines.

G. Exhaust/stack temperature

H. Inlet water temperature

I. Outdoor/ambient air temperature

J. The control can be optionally configured to perform sequencing functions for up to eight (8) boilers installed in the same hydronic loop. Sequencing functionality shall be integral to the boiler control and thus does not require an external control panel.

1. General configuration of the boiler control for integrated sequencing capabilities:
    a. One (1) boiler in the system must be factory programmed as the MASTER and subsequent boilers will be programmed as lag units.
        1) If at any point the MASTER boiler is taken out of the hydronic system, lag boilers will default to local control.
2. The boilers will communicate with each other via a ModBus network (twisted pair, daisy chain).
3. If Building Management System communication is required, this shall be accomplished through interfacing with the MASTER boiler.
    a. Modbus protocol will be standard. BACnet MSTP and IP protocol options shall be available.
    b. Lag boilers shall not require a dedicated gateway for the Building Management System to monitor status.
    c. The Building Management System will only be required to communicate through the MASTER boiler.
    d. A communication point mapping list shall be provided.

K. Outdoor reset controls for multiple boiler systems using the integrated control:

1. The following sensors shall be provided:
    a. Outdoor air/ambient temperature sensor and module.
    b. Hydronic supply water temperature sensor and well.
2. The MASTER boiler shall be field programmed with the customer's desired outdoor reset schedule.
3. The MASTER boiler shall have the ability to disable the entire hydronic boiler system based on a programmable outdoor air temperature (warm weather shutdown).

L. Sequencing logic of multiple boilers using the capabilities of the integrated control:

1. Boilers will be rotated based on a sequenced order and a programmable number of run hours.
2. Boilers will be enabled/disabled at a programmable minimum firing rate and modulated in parallel to meet load requirements. For example in a two boiler system:
    a. Upon call for heat in the system, the first boiler will be enabled and will modulate to the programmed minimum firing rate, for example 20%. This value is adjustable in the field.
    b. If the heating load is not satisfied, the second boiler will be enabled also at 20%.
    c. Both boilers will modulate up and down in parallel with infinite modulation points to meet heating load requirements.
    d. As the load decreases, the boilers will be sequentially disabled.

3. Each individual boiler can enable/disable up to three (3) devices. The enable of each device, for example a pump or motorized isolation valve, will be simultaneous with the heat demand for that boiler. The disable of each device will be based on a programmable time delay when the heat demand is no longer present.

M. Burner selection:
1. The burner shall be a premix low emission design with a build in flame arrestor functionality.

N. The burner shall feature direct spark ignition. Pilot assemblies are not accepted.

O. Boiler safety controls shall include:
1. Operating Temperature Limit for automatic start and stop.
2. High Temperature Limit with manual reset.
3. Low Water Safety Relay monitoring a probe in the boiler pressure vessel.
4. Air Safety Switch to prevent operation unless sufficient combustion air is proven.
5. Flame detector to prove combustion.

P. All controls are to be burner or panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to UL requirements. Electrical power supplied shall be 120/60/1.

2.6 MAIN FUEL TRAIN COMPONENTS

A. A factory mounted main fuel train shall be supplied. The fuel train shall be fully assembled, wired, and installed on the boiler and shall comply with CSD-1 code. The fuel train components shall be enclosed within the boiler cabinet.

B. A lock up regulator upstream of the fuel train shall be furnished by the boiler manufacturer as a standard component integral to the boiler cabinet. Factory test fire of the boiler with the provided lock up regulator is required.

C. Standard CSD-1 fuel train shall comply with IRI, which has been replaced by GE GAP.

2.7 BOILER FITTINGS AND TRIM

A. The boiler shall be supplied with an ASME Section IV safety relief valve. The safety relief valve size shall be in accordance with ASME code requirements.

B. The boiler shall be supplied with a combination temperature and pressure gauge to be mounted on the water outlet piping of the boiler.

C. A condensate drain connection shall be available on the boiler, allowing flue gas condensate to freely drain out of the exhaust manifold of the boiler. A condensate drain trap assembly shall accompany the boiler system, with pH neutralization accommodations available upon request.

1. Condensate drain piping must be galvanized or stainless steel.

D. The water supply and return connections on the boiler shall not be designed to support any external structural load from the piping system.

E. The boiler shall come with lifting eyes and fork truck accessibility for rigging.

F. Instructions for installation, operation and maintenance of the boiler shall be contained in a manual provided with each boiler.

G. A wiring diagram corresponding to the boiler configuration shall be included with each boiler.

H. Each boiler shall be installed and operated in a functioning hydronic system, inclusive of venting, as part of the manufacturing process. A factory test fire report corresponding to the boiler configuration shall be included with each boiler.

2.8 EMISSIONS

A. When operating on Natural Gas, the boiler shall have CO emissions less than 50 ppm corrected to 3% O2 and NOx emissions less than 20 ppm corrected to 3% O2, over the entire turndown range.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials shall be installed in an approved manner and in accordance with the boiler manufacturers' installation requirements.

B. The installer shall construct a level continuous concrete pad for the entire boiler system according to the boiler manufacturer's erecting instructions.

C. Assemble unit sections and parts shipped loose or unassembled for shipment purposes. Follow manufacturer's installation recommendations and instructions.

D. Install electrical control items furnished by manufacturer per wiring diagram provided by manufacturer.

E. Complete water piping installation as required by manufacturer for operation of system.

F. Provide air intake and exhaust piping, size and type as recommended by the manufacturer.

G. Provide boiler manufacturer recommendation manifold pipe and fittings from each boiler to nearest floor drain or as indicated.

3.2 CLEANING

A. Flush and clean boilers upon completion of installation in accordance with manufacturer's instruction.

B. Include boiler in system for cleaning covered in Section 23 21 13.

3.3 FIELD QUALITY CONTROL

A. Test assembled boiler, boiler piping and accessories, including, but not limited to, safety and safety relief valves, gauges, etc., in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.

B. Arrange with Owner's insurance carrier and State Boiler Inspector for inspection and certification of completed boiler unit.

C. Instruct the Owner's Representative in the proper operation of the boiler in the presence of the Boiler Representative.

3.4 WATER QUALITY

A. Initial fill of boiler water system shall be treated with softeners and/or inhibitors as recommended by Boiler Manufacturer.

B. Submit a water quality analysis by a qualified water treatment company to Boiler Manufacturer for his use in recommending water treatment.

C. Submit water quality analysis and treatment recommendations to Engineer for review and comment.

3.5 START UP

A. Manufacturer representative shall provide factory trained personnel to start up and checkout boilers. Adjust burner to provide optimum combustion as determined from flue gas analysis.

3.6 SPARE PARTS

A. Provide an additive alternative price to the bid to provide the following boiler spare parts to the Owner for future use:

1. Six (6) Bulbs for Indicating Lights
2. One (1) Flame Rod
3. One (1) Ignition Rod
4. One (1) Flame Safeguard Control
5. One (1) Blower Motor
6. One (1) Blower Sheave
7. One (1) Pilot Solenoid Valve

END OF SECTION 235200

SECTION 23 5700 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. ASME construction:

1. Provide exchanger with ASME "U" stamp.
2. Provide inspection certificate.

B. Submittals: Submit manufacturer's product data.

1. Include the following:
   a. Materials.
   b. Design working pressure and temperature.
   c. Entering and leaving conditions…
   d. Fouling factors.
   e. Flow rates.
   f. Pressure drops.

PART 2 - PRODUCTS

2.1 PLATE TYPE HEAT EXCHANGERS

A. Manufacturers:

1. Acceptable Manufacturers:
   a. Sondex
   b. Polaris
   c. Bell & Gossett
   d. Baltimore Air Coil
   e. Alpha-Laval
   f. Graham
   g. American Standard
   h. Tranter

B. Construction:

1. Plates: Stainless steel.
2. Frames: Carbon steel.
   a. Finish: Baked enamel.
3. Gaskets: Nitrile rubber.
4. Nozzles: 150 lb. Steel flanged.

PART 3 - EXECUTION

3.1 INSTALLATION OF PLATE TYPE HEAT EXCHANGERS

A. Coordinate with piping arrangement so that plates may be removed.

END OF SECTION 235700

SECTION 23 6426 - AIR-COOLED WATER CHILLERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Chiller package.

B. Charge of refrigerant and oil.

C. Controls and control connections.

D. Chilled water connections.

E. Starters.

F. Electrical power connections.

1.2 RELATED SECTIONS

A. Section 23 23 00 - Refrigerant Piping.

B. Section 23 09 00 –Building Automation and Automatic Temperature Control System.

1.3 REFERENCES

A. ANSI/ARI 550/590 - Centrifugal or Rotary Water - Chilling Packages.

B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

C. ANSI/ASHRAE 90.1 - 2004 - Energy Conservation in New Building Design.

D. ANSI/ASME SEC 8 - Boiler and Pressure Vessel Code.

E. ANSI/NEMA MG 1 - Motors and Generators.

F. ANSI/UL 465 - Central Cooling Air Conditioners.

G. ANSI/UL 984 - Safety Standard for Hermetic Motor Compressors.

H. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.

I. ASTM B117 - Standard Method of Salt Spray (Fog) Testing.

J. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

K. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products.

L. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments.

1.4 QUALITY ASSURANCE

A. Factory Test: Chiller shall be pressure-tested, evacuated and fully charged with refrigerant and oil, and shall be factory operational run tested with water flowing through the vessel.

B. Unit shall be delivered to job site fully assembled, and charged with refrigerant and oil by the Manufacturer. Cover unit with shrink wrapping or tarping to protect unit during shipping to the jobsite.

C. Unit shall be stored and handled per Manufacturer's instructions.

1.5 SUBMITTALS

A. Submit drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate accessories where required for complete system.

B. Submit product data indicating rated capacities, weights, specialties, and accessories, electrical requirements and wiring diagrams.

C. Submit manufacturer's installation instructions.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation data.

B. Include start-up instructions, maintenance data, controls, and accessories.

C. Submit maintenance data.

1.7 REGULATORY REQUIREMENTS

A. Conform to ANSI/ARI 550/590 Standard for testing and rating of Centrifugal and Rotary Screw Water - Chilling Packages.

B. Conform to ANSI/UL 465 code for construction of water chillers and provide UL label. In the event the unit is not UL approved, the manufacturer shall, at his expense, provide for a field inspection by an UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative.

C. Conform to ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of water chillers.

1.8 STORAGE AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Factory coil shipping covers shall be kept in place until installation.

C. Unit controls shall be capable of withstanding 203 Deg F (95 Deg C) storage temperatures in the control compartment for an indefinite period of time.

1.9 WARRANTY

A. Provide a full parts and labor warranty for one year from start-up or 18 months from shipment, whichever occurs first.

B. Provide five year warranty for parts and labor for motor/transmission/compressors.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install air-cooled water chillers and shown as scheduled on the Contract Documents. The chillers shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. APPROVED MANUFACTURERS

1. Trane
2. MultiStack / AirStack

2.2 GENERAL UNIT DESCRIPTION

A. Provide factory assembled and tested outdoor air-cooled liquid chillers consisting of scroll compressors, condenser, evaporator, thermal or electronic expansion valve, refrigeration accessories, starter and control panel. Construction and ratings shall be in accordance with ANSI/ARI 550/590.

B. Air cooled water chiller shall have an IPLV rating (Integrated Part Load Value) as scheduled based on ARI Standard 590-92.

2.3 COMPRESSORS

A. Provide hermetic scroll compressors. Compressors shall be industrial grade, energy efficient direct drive 3600 RPM maximum speed scroll compressor type. The motor shall be a suction-gas cooled hermetic design. A solid state temperature sensor shall be embedded in the motor windings to protect against excessive winding temperatures.

B. Statically and dynamically balance rotating parts.

C. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation.

D. Provide compressor with automatic capacity reduction equipment consisting of compressor staging (scroll). Use lifting mechanism operated by oil pressure. Compressor must start unloaded for soft start on motors.

E. Provide constant speed 3600 rpm compressor motor, suction gas cooled with solid state sensor and electronic winding overheating protection, designed for across-the-line or star delta starting. Furnish with starter. Compressor motor power factor shall be .90 or greater. If the compressor motor power factor is less than .90, power factor correction capacitors must be installed.

F. Provide crankcase heater to evaporate refrigerant returning to crankcase during shut down. Energize heater when compressor is not operating.

2.4 EVAPORATOR

A. Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally finned copper tubes, roller expanded into tube sheets.

B. Design, test, and stamp refrigerant side for 300 psig working pressure and water side for 215 psig working pressure, in accordance with ANSI/ASME SEC 8.

C. Insulate with 0.75-inch (20 mm) minimum thick flexible elastomeric rubber closed cell insulation with maximum K value of 0.26. Provide heat tape to protect evaporator to -20 degrees F (-29 degrees C).

D. Provide water drain connection, vent and fittings for factory installed leaving water temperature control and low temperature cutout sensors.

E. Evaporator shall have only one entering and one leaving connection. If manufacturer provides 2 separate evaporators, contractor shall provide manifold and pressure gauges to ensure equal flow is provided to each evaporator.

2.5 CONDENSER AND FANS

A. Construct condenser coils of aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 506 psig (3488 kPa).

B. Provide vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Entire fan assembly shall be statically and dynamically balanced and fan assembly shall be either painted or zinc coated steel. Fan guard shall be either PVC, chrome or zinc coated.

C. Provide factory mounted louvered, painted steel “architecturally pleasing” guard panels. Panel louvers shall cover condenser, evaporator and compressor sections so all are hidden from sight. Wire screens or wire mesh will not be allowed.

2.6 ENCLOSURES

A. House components in 12 gauge galvanized steel frame and mounted on welded structural steel base. Hot-dip galvanized steel frame coating shall be Underwriters Laboratories Inc. UL

recognized as G90-U, UL guide number DTHW2.

B. Unit panels and control panels shall be finished with a baked on powder paint. Control panel doors shall have door stays. Paint system shall meet the requirements for outdoor equipment of Federal Government Agencies.

C. Mount starters and disconnects in weatherproof panel provided with full opening access doors. Provide lockable disconnect operating handle external to panel and clearly visible from outside of unit indicating if power is on or off.

D. Casings fabricated from steel that do not have a zinc coating conforming to ASTM A 123 or ASTM A525 shall be treated for the prevention of corrosion with a factory coating or paint system. The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B 117. Each specimen shall have a standard scribe mark as defined in ASTM D 1654. Upon completion of exposure, the coating or paint system shall be evaluated and rated in accordance with procedures A and B of ASTM D 1654. The rating of failure at the scribe mark shall be not less than six (average creepage not greater than 1/8 inch). The rating of the unscribed area shall not be less than ten (no failure). Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry-film thickness.

2.7 REFRIGERANT CIRCUIT

A. All units 40 tons and larger shall have 2 refrigeration circuits, each with one, two, or three compressors per circuit. Units smaller than 40 tons may have 1 refrigeration circuit with two or more compressors.

B. Provide for each refrigerant circuit:

1. Liquid line shutoff valve.
2. Filter dryer (replaceable core type).
3. Liquid line sight glass and moisture indicator.
4. Electronic or thermal expansion valve sized for maximum operating pressure.
5. Charging valve.
6. Discharge and oil line check valves.
7. Compressor suction and discharge service valves.
8. High side pressure relief valve.
9. Full operating charge of R-410 and oil.
10. Unit factory leak tested at 200 psig.

C. Capacity Modulation: Unit shall be capable of operation down to 10%. In the event a manufacturer cannot provide unit with modulation down to 10%. Hot Gas Bypass must be provided.

2.8 SOUND POWER LEVELS

A. Provide low-sound fans, if required, to meet the following criteria.

B. Unit shall have a sound power rating of 95 dBA maximum when tested in accordance with ARI Standard 370.

C. Unit shall have a sound pressure rating of 67 dBA maximum at 30 feet from unit. No reduction of sound levels by obstructions on sit is allowed in determining ratings.

2.9 STARTER AND CONTROLS CABINET

A. On chiller, mount weatherproof control panel, containing starters, power and control wiring, fused disconnect switch, UL approved with external lockable operator handle or Main circuit breaker with AIC rating per electrical one-line in compliance with NEC. Provide single point power connection. Provide primary and secondary fused control power transformer and a single 115 volt single phase connection for controls and evaporator heat tape.

B. For each motor, provide wye-delta closed transition starter on 460V applications.

C. Provide the following safety controls with indicating lights or diagnostic readouts.

1. Low chilled water temperature protection.
2. High refrigerant pressure.
3. Low oil flow protection.
4. Loss of chilled water flow.
5. Contact for remote emergency shut-down.
6. Loss of refrigerant charge protection.
7. Motor current overload.
8. Phase reversal/unbalance/single phasing.
9. Over/under voltage.
10. Failure of water temperature sensor used by controller.
11. Compressor status (on or off).

D. Provide the following operating controls:

1. Eight (8) or more step leaving chilled water temperature controller which cycles compressors and activates cylinder unloaders or slide valve based on PI algorithms. If manufacturer is unable to provide at least 8 steps of unloading, providing hot gas bypass shall be required.
2. Five minute solid state anti-recycle timer to prevent compressor from short cycling. If a greater than 5 minute solid state anti recycle timer is provided, hot gas bypass shall be provided to insure accurate temperature control in light load applications.
3. Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance tripouts.
4. Low ambient controls for operation down to 15 degrees F or lower.
5. High ambient unloader pressure stat that unloads compressors to keep head pressure under control and help prevent high pressure nuisance tripouts on days when outside ambient is above design.
6. Compressor current sensing unloader unit that unloads compressors to help prevent current overload nuisance tripouts.
7. Auto lead-lag functions that constantly evens out running hours and compressor starts automatically. If contractor cannot provide this function then cycle counter and hour meter shall be provided for each compressor so owner can be instructed by the contractor

on how to manually change lead-lag on compressors and even out compressor starts and running hours.

8. Low ambient lockout control with adjustable setpoint.
9. Condenser fan sequencing which automatically cycles fans in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing unit efficiency.

E. Provide pre-piped gauge board with pressure gauges for suction and discharge refrigerant pressures or digital display of pressures on microprocessor.

F. Provide ammeters for each compressor or digital display of % RLA on microprocessor.

G. Provide remote mounted alarm and display panel with a minimum of the following features.

1. Leaving chiller water temperature setpoint adjustment.
2. Display diagnostics in 2.9 C.
3. Display entering and leaving water temperatures.
4. Display active chilled water and current limit setpoint.
5. Display ambient temperature.
6. Display parts failures:
   a. Water temperature and ambient temperature sensors.
   b. Motor contactors.
   c. Unit Controller.
   d. Condenser and evaporator refrigerant temperature sensors.

2.10 BUILDING MANAGEMENT SYSTEM

A. Provide communication interface utilizing a single twisted wire pair link to The Building Automation System. All information available at the chiller, operating codes, monitoring information, setpoint adjustments, chiller sequencing and diagnostic shall be available at BMS display.

B. Provide 4-20 mA control signal from building automation system for leaving water temperature and demand limiting setpoint adjustment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Align chiller package on steel or concrete foundations.

C. Install units on vibration isolators.

D. Connect to electrical service.

E. Connect to chilled water piping.

F. Arrange piping for easy dismantling to permit tube cleaning.

G. Coordinate all required electrical connections with electrical contractor including:

1. Single-point chiller connection
2. 120v heat tape connection

3.2 MANUFACTURER'S FIELD SERVICES

A. Supply service of factory trained representative for a period of 5 days to supervise testing, start-up, and instruction on operation and maintenance to Owner.

B. Supply initial charge of refrigerant and oil.

END OF SECTION 236426

SECTION 23 6428 - ROTARY WATER CHILLERS (130 Ton 450 Ton Water-Cooled) (Alternate 1)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Chiller package.

B. Charge of refrigerant and oil.

C. Controls and control connections.

D. Chilled water connections.

E. Condenser water connections.

F. Starters.

G. Electrical power connections.

1.2 RELATED SECTIONS

A. Section 23 21 13 - Hydronic Piping.

B. Section 23 23 00 - Refrigeration Piping and Specialties.

C. Section 23 09 00 - Controls and Instrumentation.

D. Section 26 __ __ - Equipment Wiring Systems.

1.3 REFERENCES

A. ANSI/ASHRAE STANDARD 15-1992 - Safety Code for Mechanical Refrigeration.

B. ANSI/ASHRAE 90A - Energy Conservation in New Building Design.

C. ANSI/ASME SEC VIII - Boiler and Pressure Vessel Code.

D. ANSI/ASME B31.S-1983 ASME Code for Pressure Piping and Refrigeration Piping.

E. ANSI/UL 465 - Central Cooling Air Conditioners.

F. UL 984 - Safety Standards for Hermetic Motor Compressors.

G. ARI STANDARD 550-92 - Centrifugal or Rotary Water Chilling Packages.

H. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.

I. ARI STANDARD 575-87 - Method of Measuring Machinery Sound Within Equipment Rooms.

1.4 SUBMITTALS

A. Submit drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.

B. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

C. Submit manufacturer's installation instructions.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation data.

B. Include start-up instructions, maintenance data, controls, and accessories. Include trouble-shooting guide.

C. Submit maintenance data.

1.6 VERIFICATION OF CAPACITY AND EFFICIENCY

A. The chiller (one of each size) shall be factory performance tested under full load conditions in an ARI certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer for inspection. The performance test shall be conducted in accordance with ARI Standard 550-92 procedures and tolerances.

B. All proposals for chiller performance must include an ARI approved selection method. Verification of date and version of computer program selection or catalog is available through the Vice President, Engineering, ARI (703) 524-8800.

C. The performance test shall be run with clean tubes in accordance with ARI 550-92 to include the following:

1. A downward temperature adjustment per Section A7.3 shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.
2. An upward temperature adjustment per Section A7.3 shall be made to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.
3. Test temperature adjustments can be verified prior to test by the Vice President, Engineering, ARI. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments in (1) and (2). The manufacturer shall clean

tubes, if necessary, prior to test to obtain a test fouling factor of .0000 hr. sq. ft. F/BTU.

D. The factory test instrumentation shall be per ARI Standard 550, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology (formerly NBS).

E. A certified test report of all data shall be submitted to the Contracting Officer prior to completion of the project. The factory certified test report shall be signed by an officer of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.

F. The equipment will be accepted if the test procedures and results are in conformance with ARI Standard 550-92. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the owner or his representative to witness the retest. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed:

1. APACITY TEST: For each ton below the allowable capacity as set forth in ARI 550-92 of the design capacity, five hundred dollars per ton will be deducted from the contract price.

   Allowable capacity = (1 - tolerance) x design capacity; tolerance per ARI 550-92, Section 5.4.

2. POWER CONSUMPTION TEST: The power consumption penalty for all load points shall be based upon the tolerances set forth in ARI 550-92. The power consumption penalty (P.C.P.) will be calculated based upon the following formula:

   P.C.P. = [Measured KW - (Measured Tons x Allowable KW/Ton*)] x $1000/KW.

   *Allowable KW/Ton = (1 + tolerance) x design KW/Ton; tolerance per ARI 550-92, Section 5.4.

3. TOTAL PERFORMANCE PENALTY: The total performance penalty will be the sum of CAPACITY PENALTY AND POWER CONSUMPTION PENALTY, times the number of typical chillers, regardless if tested.

G. Equipment manufacturer shall not invoice for the centrifugal chillers(s) until successful completion of the performance test or acceptance of penalty deduction from the contract.

1.7 REGULATORY REQUIREMENTS

A. Conform to ARI Standard 550-92 code for rating and testing of centrifugal and rotary chillers.

B. Conform to ANSI/UL 465 for construction of centrifugal chillers and provide UL label.

C. Conform to ANSI/ASME SECTION VIII Boiler and Pressure Vessel Code for construction and testing of centrifugal chillers.

D. Conform to ANSI/ASHRAE STANDARD 15-1992 code for construction and operation of centrifugal chillers.

E. Unit shall bear the ARI Certification Label for Centrifugal/Rotary Water-Cooled Chillers as applicable.

1.8 HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.9 WARRANTY

A. Provide five year warranty.

B. Warranty: Include coverage for complete chiller package as manufactured and delivered to site including materials and labor.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install Series R or centrifugal water chillers as shown and scheduled in the plans. The units shall be installed in accordance with this specification and produce the specified tonnage per the scheduled data in accordance with ARI 550-92. The unit shall bear the ARI certification label as applicable.

B. Approved manufacturers:

1. Trane
2. York

2.2 COMPRESSOR AND MOTOR

A. The compressor shall be rotary screw type. Compressor shall be semi-hermetic, field rebuildable and utilize horizontal rotors. No hermetic "tin can" compressors are acceptable. Vertical rotor compressors are not acceptable.

B. Chiller should be able to unload to 15 percent of design tonnage with constant entering condenser water temperature.

C. The motor shall be semi-hermetic and either suction or liquid refrigerant cooled. Hot gas motor cooling is not acceptable.

D. Motors shall have 3 RTDs in the motor windings, one per phase, to protect against high motor temperature at start-up.

E. Manufacturers with speed increasing transmissions that exceed 10,000 RPM compressor speeds shall annually inspect the gears and bearings. A report shall be forwarded to the owner each year over the first five years to confirm completion.

F. The impellers shall be fully shrouded and made of a high strength aluminum alloy. Impellers shall be dynamically balanced and over-speed tested at 1.25 times impeller shaft speed. Rotors shall be of high grade steel alloy.

2.3 EVAPORATOR AND CONDENSER

A. The evaporator and condenser shall be built in accordance with ANSI/ASHRAE 15-1992 Safety Code for Mechanical Refrigeration. Marine waterboxes shall be designed for 300 psig maximum working pressure. Marine waterboxes shall have grooved connections on both evaporators and/or condensers.

B. Evaporator and Condenser tubes shall be internally enhanced and externally finned to achieve maximum efficiency. The nominal tube wall thickness shall be .028 inches for both evaporator and condenser tubes.

C. Units with multi-stage compressors shall incorporate an interstage flash vessel economizer in the refrigerant cycle. All units utilizing subcooling must be provided with a thermometer well to monitor the amount of subcooling.

D. Factory insulation will be 3/4" foam insulation and cover all low temperature surfaces to include the evaporator and water boxes, suction elbow, economizer, motor housing, and motor cooling lines.

2.4 PURGE OR PUMP-OUT SYSTEM

A. The manufacturers of low pressure chillers (R-11, R-123, etc.) must provide a separate purge system that operates independently of the unit and can be operated while the machine is shut down. A purge pressure gauge, number of starts counter, and hour meter shall be included on the purge system.

B. Units operating with refrigerant having positive pressure at 75 F (R-22, R-134A etc.) shall have the capability of storing the entire refrigerant charge in the condenser or shall have a pump-out system for each machine complete with a separate transfer pump, condensing unit and tank constructed in accordance with ASME Code for unfired pressure vessels bearing the National Board stamp. Pumpout systems shall be supplied and warranted by the centrifugal machine manufacturer. Pump-outs shall comply with the following:

1. Pump-out tank(s) with ASME stamp capable of holding refrigerant charge when 80 percent full at 90F.
2. Separate charging connections for liquid and gas refrigerant.
3. Piping and valves between pumpout and chiller to be supplied and installed by installing contractor. Contractor shall provide all piping, electrical equipment, and wiring required.

Refrigerant piping shall be Type K hard-drawn copper with wrought copper fittings. Valves shall be packless type suitable for refrigerant use.

C. The chiller(s) shall be controlled by a stand-alone direct digital control (DDC) system. A dedicated chiller control panel is to be supplied with each chiller by the chiller manufacturer. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.

2.5 CONTROLS

A. The chiller(s) shall be controlled by a stand-alone direct digital control (DDC) system. A dedicated chiller control panel is to be supplied with each chiller by the chiller manufacturer. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.

B. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays, and switches. The panel shall be a complete system for stand-alone chiller control and include controls to safely and efficiently operate the chiller.

C. Safeties - The chiller control panel shall monitor such safeties as motor starting and operation, time between compressor starts, low chilled water temperature, high condenser refrigerant pressure, low evaporator refrigerant pressure, evaporator and condenser water flows, low oil flow, discharge temperature, phase imbalance protection, phase loss protection, reverse rotation protection, under/over voltage protection (as optional), and proper operation of unit controls and sensors.

D. The chiller control panel is to be provided with the following digital type pressure readouts:

1. Evaporator refrigerant pressure.
2. Condenser refrigerant pressure.

E. The front of the chiller control panel shall be capable of displaying the following in Clear Language as standard:

1. Entering and leaving evaporator water temperature.
2. Entering and leaving condenser water temperature.
3. Chilled water setpoint.
4. Electrical 3 phase current limit and percent RLA setpoint.
5. Electrical 3 phase amp draw.
6. Chiller operating mode.
7. Condenser refrigerant temperature.
8. Elapsed time and number-of-starts counter.
9. Chiller compressor run status relay.
10. Diagnostics with time and date stamp.
11. Last 20 diagnostics with time and date stamp.

F. The chiller control panel shall provide evaporator freeze protection and low limit control (as standard). This control shall be used to avoid low evaporator refrigerant temperature tripouts during critical periods of chiller operation. The control shall take progressively more aggressive

load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature. A Clear Language Display, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.

G. The chiller control panel shall provide a relay output (as standard) to start the condenser water pump and/or enable the cooling tower temperature controls.

H. The chiller control panel shall provide an alarm relay output (as standard) that shall energize whenever a fault requiring manual reset is detected by the panel.

I. The chiller control panel shall provide condenser limit control (as standard) to include a temperature sensor used to sense the saturated refrigerant temperature and then convert it to a pressure. The pressure shall then be displayed on the Clear Language Display panel. This control shall be used to avoid high condenser refrigerant pressure tripouts during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and actual value of the condenser refrigerant pressure.

J. The chiller control panel shall provide a limit relay output (as standard) that shall energize whenever the unit is operating in a limit mode (for extended time periods).

K. The chiller control panel shall provide a programmable soft load (as standard) to prevent the chiller from achieving full capacity during the cooldown period by imposing a current limit or decreasing the rate of loading during the initial pull down (load limiting).

L. The chiller control panel shall provide a factory and field service starter dry-run feature (as standard). Starter dry-run shall be enabled at the operator interface. Before a chiller is put on line, the starter is sequenced to confirm that the wiring and components have been properly installed. The sequence must be done without the main power connected to the motor.

M. The chiller control panel shall provide a chilled water pump output relay (as standard) that closes when the chiller is given a signal to start.

N. The chiller control panel shall provide control of leaving chilled water setpoint with a minimum variation of chiller capacity (as standard).

O. The chiller control panel shall provide an informational diagnostic that allows the operator to detect an early refrigerant loss in the chiller. If manufacturer cannot supply a diagnostic from the control panel, then the manufacturer or contractor must supply a semi-annual refrigerant level inspection for the first five years of operation.

P. The chiller control panel shall provide a RS-232 for printer interface to a printer.

Q. The chiller control panel shall provide leaving chilled water temperature reset based upon ambient (as optional).

R. The chiller control panel shall provide a relay on line and/or signal the operator when the chiller experiences high head pressures (as optional).

S. The chiller shall have factory mounted and tested controls that provide dual chilled water setpoint control for ice-making application (as optional). Controls shall be compatible with Climatice ice storage tanks.

T. The chiller control panel shall provide a relay to signal when the chiller is at maximum capacity (as optional).

U. The unit control panel shall provide input for leaving chilled water temperature setpoint based upon a 4-20ma or 0-10 VDC signal from a building automation system (as optional).

2.6 STARTERS (LOW VOLTAGE)

A. The motor starter shall be a [star delta closed transition] or [solid state starter]. Motor starter shall have NEMA 1A gasketed enclosure. Enclosure shall be constructed of 12 gauge steel minimum with the exception of doors which shall be 14 gauge steel minimum. Unit mounted enclosures shall have ventilating louvers. Gasketing shall be 2" width minimum. Each door or enclosure more than 48" high shall have three-point vault type latches with padlockable handles.

B. Contactors shall be sized properly to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall be low resistance having palladium silver contacts.

C. Solid state starter SCRs shall be sized properly to the chiller full load and locked rotor currents. Auxiliary interlocks that interface with the control panel shall be low resistance having palladium silver contacts.

D. Each motor starter shall include a control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.

E. Power wiring within the starter shall be type MTW copper stranded 90 degree C. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be type MTW copper stranded 90 degree C 14 gauge minimum.

F. Starter shall include an advanced motor protection system incorporating electronic three phase overloads and current transformers. This electronic motor protection system shall monitor and protect against the following conditions:

1. Three phase overload protection.
2. Overload protection during start-up.
3. Phase imbalance.
4. Phase loss.
5. Phase reversal.
6. Low voltage.
7. Distribution fault protection consisting of three- phase, current sensing devices that monitor the status of the current. Distribution faults of 1-1/2 electrical cycle durations

shall be detected and the compressor motor shall be disconnected within six electrical cycles.

8. Under/over voltage protection (optional).

G. Alternately the advanced motor protection system can be furnished in the chiller control panel.

H. The starter/control shall be designed and able to operate in temperatures up to 122 F (50 C).

I. All field supplied wires, bus bars, and fittings shall be copper only.

J. The following optional starter options shall be provided:

1. A non-fused disconnect switch shall be provided.
2. Amps (standard) and volts (optional) shall be displayed at the control panel or ammeters and voltmeters provided. Three ammeters shall be provided, one per phase. Ammeters shall be calibrated to indicate the inrush current. Three voltmeters shall be provided, each reading a phase-to-phase voltage.
3. U.L. approval.

K. If solid state starter is provided one of the following trip mechanisms must be provided:

1. Shunt-Trip Circuit Breaker: Starter shall contain circuit breaker with shunt trip device capable of breaking currents up to its interruption capacity of [_____]. Operating handle and trip indicator shall be located in the door. The disconnect handles, both internal and external, shall be capable of being padlocked in the off position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide for connection to electrical service. If oil pump is electric include the connection of the oil pump to separately fused circuit.

C. On units without unit mounted starters provide for connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit.

D. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.

E. Arrange piping for easy dismantling to permit tube cleaning.

F. Provide piping from chiller relief valve outdoors. Size as recommended by manufacturer.

3.2 MANUFACTURER'S FIELD SERVICES

A. Manufacturer shall furnish a factory trained service engineer without additional charge to start the unit(s). Representatives shall provide leak testing, evacuation, dehydration, and charging of

the unit(s) as required. Chiller manufacturers shall maintain service capabilities no more than 50 miles from the jobsite.

B. A start-up log shall be furnished by the manufacturer to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.

C. The manufacturer shall furnish an alternate price for:

1. Extended parts warranty for five years.
2. Extended parts and labor warranty for five years.

D. The manufacturer shall furnish complete submittal wiring diagrams of the chiller(s) starter(s) and associated components like cooling towers, pumps, interlocks, etc. as applicable.

END OF SECTION 236428

SECTION 23 6500 - COOLING TOWERS (Alternate 1)

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's data including:

1. Overall dimensions.
2. Operating weights.
3. Support loading points and loads.
4. Fan cfm and brake horsepower.
5. Motor data.
6. Sizes and locations of connections.
7. Installation instructions.
8. Maintenance manuals.
9. Sound power levels.

1.2 TESTING

A. Tower shall be capable of passing a capacity test conducted in accordance with the Cooling Tower Institute's Acceptance Test Code for Water Cooling Towers. CTI STD. 201.

B. Testing will be done at the discretion of the Owner, and it is not part of the work of this Section.

1.3 APPROVALS

A. Tower to be Factory Mutual (FM) approved.

PART 2 - PRODUCTS

2.1 INDUCED DRAFT CROSS FLOW TOWERS

A. Manufacturers:

1. Design Basis: Baltimore Air Coil.
2. Other Acceptable Manufacturers:
   a. Marley.

B. Casing: Watertight galvanized steel (G235 STD).

C. Collecting Basin:

1. Material: Galvanized steel (G210 STD).
2. Water Connections:
   a. As shown on plans.

D. Fill:

1. Material: PVC (min. 15 mil.) or galvanized steel.
2. Fire Rating: Comply with NFPA 220.
3. Drift Eliminators: PVC, shall limit drift to 0.005% of design flow rate.

E. Louvers: Galvanized steel or PVC (min. 17 mil.)

F. Water Distribution System: Galvanized steel open basin with plastic metering orifices.

G. Basin Covers:

1. Material: Galvanized steel (G210 STD).
2. Type: Removable.

H. Guards:

1. Provide guards for exposed parts of belt or gear drives.
2. Refer to Section 23 05 02, Article 2.05.

I. Handrails and Ladders:

1. Material: Galvanized steel, or aluminum.
2. Railing around top working surfaces, and ladder to them with safety cage.
3. Provide access door platform with rail.

J. Fan:

1. Type: Propeller.
2. Drive: Belt, gear or direct.
3. Capacity Adjustment:
   a. Variable Speed Drive.

K. Motor:

1. Type: Totally enclosed fan cooled, single winding.
2. For details, refer to Section 23 05 13.
3. Location: Out of humid airstream.

L. Make-Up Valve:

1. Brass.
2. Electronic.

M. Accessories:

1. Air inlet screen.
2. Hot water basin cover.
3. Basin heater (Sized per manufacturer's recommendations based on sump capacity and -10^0F.)

4. Vibration switch per Section 1125 of 1994 UBC, mounted by Tower manufacturer.

N. Control Panel (one per cell) with the following:

1. NEMA 3R construction with fused disconnect switch that may be padlocked.
2. Full voltage magnetic starter (two speed) utilizing an overload relay.
3. Control power transformer (120 V control power).
4. Auto-Off-Low-High selector switch.
5. Pilot lights for low or high speed running.
6. Automatic decelerating timing relay for two speed operation.
7. PENN A-19 thermostat for basin heater control.
8. Interlock switch which will prevent the basin heater and fan from operating simultaneously.
9. Automatic sensor switch to turn off the heater when there is no water in the basin.
10. Provide 120V interlock wiring between the control panel(s) for each cell to allow a single CWS sensor to stage each cell as necessary to maintain leaving condenser water temperature.
11. Provide dry electrical contacts for on/off control of system from BMS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Provide necessary auxiliary supporting steel.

C. Mount motors and drives so belts run true.

D. Wire vibration switch to de-energize fan when excessive vibration is experienced.

3.2 ADJUSTMENTS

A. Adjust drive for speed shown in submittal.

B. Check motor amps.

1. Do not overload motor.

C. Check for unusual noise or vibration.

D. Provide necessary lubrication.

E. Adjust make-up water control.

F. Adjust sump water thermostat.

END OF SECTION 236500

SECTION 23 7200 - HEAT RECOVERY EQUIPMENT (Alternate 1 & 2)

PART 1 - GENERAL

1.1 SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's data, including:

1. Performance data.
2. Drawings showing:
   a. Dimensions
   b. Support requirements
   c. Sizes and locations of connections

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Design Basis: Des Champs Laboratories, Inc.

B. Other Acceptable Manufacturers:

1. Exothermics
2. Temp-X-Changer
3. Weather-Rite

2.2 Model: 75.

A. Construction:

1. Heat Exchanger: Aluminum, .01" thick.
2. Heat Exchanger Coating: None.
3. Casing: Galvanized steel, 18 ga.
4. Access:
5. Drain: One each side.

B. Accessories:

1. Traversing defrost plate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Duct Connections:

1. Make tight.
2. Maintain separation of supply and exhaust air streams.

B. Pipe drains to floor drain.

C. Test operation of traversing defrost system.

END OF SECTION 237200

SECTION 23 7325 - DESICCANT AIR HANDLING UNITS WITH COILS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Packaged Desiccant Air Handling Units.

1.2 RELATED WORK

A. Section 23 05 13 – Motors and Starters
Section 23 82 16 – Air Coils
Section 23 40 00 – Air Cleaning
Section 23 09 00 – Automatic Temperature Controls

1.3 REFERENCES

A. ARI 430 - Standard for Central Station Air Handling Units.

B. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

C. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

D. SMACNA - HVAC Duct Construction Standards.

E. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils.

F. ANSI/UL 900 - Test Performance of Air Filter Units.

G. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.

1.4 QUALITY ASSURANCE

A. Air Handling Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product offering.

B. Air Handling Units: Certify capacity, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430-89.

C. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-87.

1.5 SUBMITTALS

Submittals should include the following:

A. Equipment schedule containing dehumidification, fan motor data, gas requirement, electrical power requirement and filtration schedule.

B. A System Flow Diagram showing air volumes and conditions throughout the systems.

C. A General Arrangement Diagram showing three views of the IceAire unit with overall dimensions, general utility connection locations, ductwork connection points and bolting patterns, total weight and required service or equipment removal clearances.

D. Control Diagrams and Parts Lists showing all electrical circuits, components rating and any applicable setpoints.

E. Recommended Spare Parts list with long and short term requirements.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 1.

B. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Design Basis: Munters Drycool.

2.2 GENERAL

A. Any exceptions to the specifications must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

B. Factory fabricate units with fan sections, coil sections, energy recovery wheel, desiccant wheel, reactivation gas burner, filter sections, access sections, as called for on the drawings and in accordance with this specification.

C. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified. Units shall be fully assembled up to practical shipping limitations. On units not shipped fully assembled, manufacturer shall tag each section to indicate location in direction of airflow to facilitate assembly at the job site.

D. Base performance on 205 feet ASL conditions.

2.3 BASE

A. Unit base shall be all bolted steel construction with formed 2”x8” 12 gauge galvanized steel channel around the outside perimeter and reinforced with 2”x___” 12 gauge galvanized steel channel around the inside perimeter. Cross support members shall be 6”x2” 12 gauge galvanized channel and welded on center not exceeding 24 inches. Completed base weldment shall be constructed with G90 galvanized materials.

B. 18 gauge galvanized steel floor panels shall be fastened to the base weldment, and all seams shall be sealed watertight. 1 inch thick ductboard insulation shall be secured to the underside of the floor panels so that it is not exposed to foot traffic. Insulation shall be mechanically secured on all sides. Base shall be provided with bolted lifting lugs.

2.4 CABINET

A. The unit housing shall be constructed of .050 embossed aluminum or 22 gauge galvalume panels. All cabinet panels shall be sealed and removable. All wall panels shall have a minimum of 1” fiberglass ductboard insulation mechanically secured on all sides with no exposed edges. The roof panels shall be formed with a standing seam and sealed with a cap to prevent water leakage. The roof shall have 2” of fiberglass ductboard insulation.

B. Access to all service areas shall be provided by full size service doors. Doors shall be furnished with a continuous aluminum extruded hinge, compression type latches, and resilient gaskets. All access doors shall have a minimum of 1 inch fiberglass ductboard insulation.

C. Unit shall include access to the electrical panel, dehumidifier components and controls, while providing protection from the weather.

2.5 DEHUMIDIFIER AND CONTROL COMPONENTS

A. Dehumidifier shall be of design and construction proven in the field by minimum of five years operating performance.

B. Dehumidifier shall be non-cyclic sorption type with a single desiccant rotary structure designed for continuous operation. Construction arrangement shall provide counter flow of process and reactivation streams with full face pressure seals to prevent cross leakage with static pressure differentials up to 8 inches water gauge.

C. The rotary structure shall consist of 100% inert silicates impregnated with an inorganic, nongranular, crystalline desiccant which transfer water in vapor phase or of a non-crystalline form of silicone dioxide (silica gel). The design shall assure laminar air flow throughout the structure for minimum pressure loss with maximum transfer surface.

D. The dehumidifier shall include: A HoneyCombe desiccant wheel and drive system, auxiliary reactivation heater, fan and motor assemblies for reactivation and process air flow, reactivation and process air flow indicating gauges, inlet filters for reactivation and process air, reactivation energy control system, and overheat, underheat and rotation fault circuitry.

2.6 ENTHALPY WHEEL AND CONTROL COMPONENTS

A. The energy recovery shall include: An enthalpy recovery wheel and drive system and exhaust fans, supply and exhaust air flow indicating gauges, inlet filter for return and makeup air, exhaust back draft damper, overload, and rotation fault circuitry.

B. The enthalpy wheel shall be made of alternating layers of corrugated and flat aluminum foils or composite materials, bonded together into a rigid transfer media forming a multitude of narrow channels to insure a laminar flow. The wheels shall be of a proven design and have been available on the market for at least 15 years. The media shall be hygroscopic aluminum for recovering sensible and latent heat at equal efficiencies at equal air flows. The media shall be cleanable by compressed air, vacuuming low temperature steam or hot water without effecting the latent heat recover. The casing shall be equipped with adjustable non-contact seals to insure a carry over maximum 0.20%.

2.7 DIRECT FIRE REACTIVATION

A. Direct fire gas reactivation may be used to reactivate the titanium silica gel wheel. The direct fire burner will be capable of an output capacity over a fully modulated range from 50,000 BTU to 700,000 BTU input at a constant airflow. The burner shall produce no measurable carbon monoxide in the airstream.

B. The stream shall be designed to meet ANSI requirements.

C. The control shall provide fully automated control of the furnace.

2.8 FANS

A. The units shall be equipped with supply, exhaust and reactivation air fans to provide the scheduled air flows that static pressures indicated. All fans shall be rated in accordance with AMCA standard 210.

B. Supply air fan shall be double width, double inlet (DWDI), or single width, single inlet (SWSI), backward airfoil and shall be belt driven with an adjustable motor sheave. DWDI fan shall be spring isolated.

C. Exhaust air fan shall be SWSI, backward airfoil and shall be belt driven with an adjustable motor sheave. Provide two motors and adjustable sheaves for exhaust fan.

D. Reactivation air fan shall be single width, single inlet with backward air foil blades. Reactivation fan shall be direct drive with an ODP motor.

E. Belt driven fans shall have shafts of ground and polished steel, coated with a rust inhibitor, and sized to operate at not more than 80% of its first critical speed. Bearings shall be self-aligning, heavy duty and sized for 200,000 hours average life. Motors shall be open drip proof NEMA design B with Class B insulation and 1.15 service factor.

2.9 FILTERS

A. Return air inlet, make up air inlet, and reactivation air inlet shall be equipped with heavy gauge galvanized steel racks to provide for easy removal of filters. Filters shall be 2 inches thick, pleated disposable type with non-woven media held in place by a wire support grid. Filters

shall be 25%-30% average efficiency per ASHRAE test standard 52-76.

2.10 DAMPERS AND LOUVERS

A. Make-up air and balancing dampers shall be constructed with heavy gauge galvanized steel frames and galvanized steel blades with oil bushings. Dampers shall be of the opposed blade type and shall include position indicating quadrants and locking hardware or motorized actuators as required.

2.11 ELECTRICAL

A. The main electrical control panel shall be located within the unit. All electrical control shall be UL listed and the entire unit factory wired in accordance with National Electrical Code standard and ETL approved. The unit shall be supplied with a non-fused main power disconnect which is mounted on the control panel and engaged by an operating mechanism on the panel cover. A single point power connection shall be provided for all units.

2.12 DESICCANT UNIT CONTROLS

A. A remote Building Automation System (BAS) control panel shall provide input to the electrical control panel mounted on the desiccant air handling unit.

B. The following input functions shall be provided from the remote BAS control panel:

1. Occupied/Unoccupied
2. Dehumidification On/Off
3. Exhaust Fan Max. Speed/Min. Speed
4. Desiccant Unit On/Off
5. Supply Fan On/Off

These functions shall be binary outputs from the BAS. An Auto/ Occupied/ Unoccupied/ Off switch on the remote BAS control panel face shall setoff the desiccant unit mode of operation. An Auto/On fan switch on the remote BAS panel face shall control supply fan operation.

C. Occupied/Unoccupied: During the occupied mode outside air damper D1 and exhaust air damper D7 are open, return air damper D8 is closed, supply and exhaust fans operate and energy recovery wheel is activated. During the occupied mode bypass return damper D2 is closed on maximum outside air and is open on minimum outside air. During the unoccupied mode, outside air damper D1 and exhaust air damper D7 are closed, return air damper D8 is open, bypass return air damper D2 is open, exhaust fan is off and energy recovery wheel is deactivated. Supply fan cycles in the fan auto mode on call for operation from the remote BAC control panel.

D. Dehumidification On/Off: On a call for dehumidification from BAS during both occupied and unoccupied modes, face and bypass dampers D3 and D4 are positioned for flow through the desiccant wheel. Desiccant wheel is activated and reactivation exhaust fan and reactivation gas burner operate. Gas burner is modulated to maintain 120°F reactivation discharge temperature.

E. Exhaust Fan Max. Speed/Min. Speed: On a call for maximum outside air from the BAS, the exhaust fan is positioned to maximum exhaust fan motor operation and bypass return damper D2 is closed. On a call for minimum outside air from the BAS the exhaust fan is positioned to minimum exhaust fan motor and bypass return air damper is open.

F. Desiccant Unit On/Off: During the off mode of operation the desiccant unit shall not operate.

G. Supply Fan On/Off: When the supply fan is in the on mode it shall operate continuously during both occupied and unoccupied modes.

H. Desiccant Unit Status: Remote control panel of BAS shall monitor dry contacts for the following status points from the desiccant unit control panel:

1. Power On
2. Energy Recovery Wheel Motor Overload
3. Desiccant Wheel Motor Overload
4. Exhaust Fan Motor (Hi) Overload
5. Exhaust Fan Motor (Low) Overload
6. Supply Fan Motor Overload
7. Reactivation Fan Motor Overload
8. Energy Recovery Wheel Rotation Fault
9. Desiccant Wheel Rotation Fault
10. Reactivation Gas Burner Fault

PART 3 - EXECUTION

3.1 GENERAL

A. Assemble and install in accordance with manufacturers written installation instructions and details on drawings.

B. Coordinate duct, piping and electrical work so as to provide access to unit for maintenance and filter replacement and coil removal with minimum disturbance of piping.

C. Prior to unit start-up all controls shall be installed and tested.

D. Prior to initial start-up and for system testing install air filters to protect the unit and ductwork from dirt and debris. After the system has been tested and prior to turning the system over to the Owner, replace the pre-filters with new, clean filters as specified.

E. Prior to turning the system over to the Owner, all damages incurred during shipping, storing and installing shall be repaired. These repairs shall be sufficient to bring the equipment back to the quality standards, equal to the original manufacturing standards. These repairs shall include but are not limited to repairing painted surfaces, dent removal, combing coil fins, repairing or replacing wet, sagging or torn insulation, etc.

F. Pipe condensate full size to nearest floor drain. Provide trap 1” greater than fan static pressure.

G. Install units with adequate clearances to access valves, open access doors fully, for coil pull and NEC clearances in front of disconnect switches.

END OF SECTION 237325

SECTION 23 7400 - PACKAGED ROOFTOP AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Package roof top unit.

B. Heat exchanger.

C. Refrigeration components.

D. Unit operating controls.

E. Roof curb.

F. Electrical power connections.

G. Operation and maintenance service.

1.2 RELATED SECTIONS

A. Section 23 05 13 – Motors and Starters.

B. Section 23 05 48 - Vibration Isolation.

C. Section 23 07 00 - Mechanical Insulation.

D. Section 23 40 00 - Air Cleaning.

E. Section 23 09 00 – Building Automation and Temperature Control Systems.

F. Division 26 - Equipment Wiring Systems.

G. ARI 370 - Sound Rating of Outdoor Unitary Equipment.

H. ANSI/NFPA 70-1990 - National Electric Code.

I. ANSI Z21.47 - Gas-Fired Central Furnaces (except Direct Vent Central Furnaces).

J. Refer to all other Specification Sections, including, but not limited to, 23 05 13, 23 05 30, and 23 05 48.

1.3 REFERENCES

A. NFPA 90 A and B - Installation of Air Conditioning and Ventilation Systems an Installation of Warm Air Heating and Air Conditioning Systems. (all)

B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration. (all)

C. ARI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard. (g/e, c/e above 135,000 btuh)

D. ARI 340 - Commercial and Industrial Unitary Heat pump Equipment. (hp above 135,000 btuh)

E. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment. (all)

F. ANSI/ASHRAE/IES 90 A - Energy Conservation in New Building Design Standard.

G. ANSI/UL 465 - Central Cooling Air Conditioners Standard for safety requirements. (g/e, c/e)

H. California Energy Commission Administrative Code - Title 20/24 - Establishes the minimum efficiency requirements for HVAC equipment installed in new buildings in the State of California. (all)

I. ARI 210/240 - Unitary Air-Conditioning Equipment and Air-Source Heat Pump Equipment. (all under 135,000 btuh)

J. ARI 270 - Sound Rating of Outdoor Unitary Equipment. (all below 135,000)

K. ANSI/NFPA 70-1990 - National Electric Code. (all)

L. ANSI Z21.47 - Gas-Fired Central Furnaces (except Direct Vent Central Furnaces). (g/e)

1.4 SUBMITTALS

A. Submit drawings indicating components, dimensions, weights and loadings, required clearances, and location and size of field connections.

B. Submit 6 copies of (submittals) product data indicating rated capacities, weights, accessories, and electrical requirements.

C. Submit manufacturer’s installation instructions.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit 6 copies of operation and maintenance manuals to the engineer.

B. Include manufacturer’s descriptive literature, start-up and operating instructions, installation instructions, and maintenance procedures.

1.6 DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer’s installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.7 WARRANTY

A. Provide a full parts warranty for one year from start-up or 18 months from shipment, whichever occurs first.

B. Include one year service guarantee on the entire refrigeration cycle and its associated interlocks. This guarantee shall obligate the installer to service the equipment and attend to all legitimate service calls and make necessary repairs, alterations, additions, adding refrigerant charges, etc. for a period of one year without additional cost to the Owner. Compressors shall carry an additional four year parts warranty with the exclusion of replacement labor. Shop drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

1.8 MAINTENANCE SERVICE

A. Furnish complete parts and labor service and maintenance of packaged roof top units for one year from Date of Substantial Completion.

B. Provide maintenance service with a two month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.

C. Include maintenance items as outlined in manufacturer's operating and maintenance data.

D. Contractor shall submit copy of service call work order or report and include description of work performed.

E. Manufacturer shall maintain a parts and service center in the city from which the units are purchased.

1.9 REGULATORY REQUIREMENTS

A. Units shall be U.L. listed and labeled, classified in accordance to ANSI Z21.47 for gas fired central furnaces, U.L. 465 for central cooling air conditioners, and U.L. 559 for Heat Pumps.

1.10 EXTRA MATERIALS

A. Provide one set of filters.

B. Furnish one complete set of fan motor drive belts.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install package rooftop unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. Approved Manufacturers

1. Trane
2. JCI
3. Daikin
4. Other acceptable manufacturers: must meet this specification.

2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be combination gas heating/electric cooling packaged rooftop(s) as scheduled on contract documents and these specifications. Cooling capacity ratings shall be based on ARI Standard 360. Unit(s) shall consist of insulated weather tight casing with compressor(s), air cooled condenser coil, condenser fans, evaporator coil, return air filters, supply motors and drives, unit controls and gas-fired heating section.

B. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

C. Units shall be dedicated downflow or dedicated horizontal airflow as manufactured.

D. Wiring internal to the unit shall be colored and numbered for identification.

2.3 UNIT CASING

A. Cabinet: Galvanized steel, phosphatized, and finished with an air-dry paint coating with removable access panels. Structural members shall be 16 gauge with access doors and removable panels of minimum 20 gauge.

B. Unit's cabinet surface shall be tested 500 hours in salt spray test in compliance with ASTM B117.

C. Cabinet construction shall allow for all service/maintenance from one side of the unit.

D. Cabinet top cover shall be one piece construction or where seams exist, it shall be double hemmed and gasket sealed.

E. Access Panels: Water and air tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section. (3-20 ton g/e, 6 ¼ -20 ton c/e, hp)

F. Downflow unit's base pans shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity. (3-20 ton g/e, 6 ¼ -20 ton c/e, hp)

G. Insulation: Provide ½ inch thick coated fiberglass insulation on all exterior panels in contact with the return and conditioned air stream.

H. The base of the unit shall have provisions for forklift and crane lifting.

2.4 AIR FILTERS

A. Air Filters: Factory installed filters shall mount integral within the unit and shall be accessible thru access panels. Two inch thick glass fiber disposable media filters shall be provided.

2.5 FANS AND MOTORS

A. Provide evaporator fan section with forward curved, double width, double inlet, centrifugal type fan.

B. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings.

C. Provide units 5 tons and below with direct drive, multiple speed, dynamically balanced supply fans.

D. Provide units 6 ¼ tons and above with belt driven, supply fans with adjustable motor sheaves.

E. Outdoor and Indoor Fan motors shall be permanently lubricated and have internal thermal overload protection.

F. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.

G. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.6 GAS FIRED HEATING SECTION

A. Completely assembled and factory installed heating system shall be integral to unit. [UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils.] Threaded connection with plug or cap provided. Provide capability for gas piping connection through side of unit.

B. Heating section shall be factory run tested prior to shipment.

C. Gas Burner shall be forced combustion type power burner, negative pressure gas valve, manual shut-off, hot surface ignition, and flame sensing safety control.

D. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Upon a failure to ignite, two attempts of ignition will occur before lockout of the ignition system.

E. Combustion blower shall be centrifugal type fan with built-in thermal overload protection on fan motor.

F. Heat Exchanger: Provide drum and tube heat exchanger of free floating design manufactured from 18-gauge aluminized steel. Factory pressure and leak tested.

G. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.

2.7 EVAPORATOR COIL

A. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.

B. Provide an independent expansion device for each refrigeration circuit. Factory pressure test at 450 psig and leak tested at 200 psig.

C. Provide drain pan for base of evaporator coil constructed of PVC or galvanized steel with external connections.

2.8 CONDENSER SECTION

A. Provide internally finned 3/8" seamless copper tube mechanically bonded to aluminum fins. Factory pressure tested to 450 psig.

B. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

C. Provide hail guards.

2.9 REFRIGERATION SYSTEM

A. Compressor(s): Provide scroll compressor with direct drive operating at 3600 rpm. Integral centrifugal oil pump, inlet dirt separator, rolling element bearings, crankcase heater, completely enclosed compression chamber with no leakage paths, scrolls have the ability to separate allowing liquid refrigerant and dirt to pass through without damaging the compressor. Provide suction gas cooled motor with over temperature and over current protection.

B. Compressor(s) shall be manufactured by the HVAC unit manufacturer.

C. Units shall have cooling capabilities down to 0 degrees F as standard or manufacturer shall furnish unit with installed low ambient controls to allow for operation down to 0 degree F. For field installed low ambient accessory, the manufacturer shall provide a factory authorized serviceman that will assure proper installation and operation.

D. Provide with thermostatic temperature control in the compressor windings, to protect against excessive temperatures, high and low pressure conditions.

E. Provide each unit with two refrigerant circuit(s) factory supplied completely piped with liquid line filter drier, suction and liquid line Schraeder valves.

F. For heat pump units, provide reversing valve, discharge muffler, flow control check valve, and electronic time initiated, temperature terminated defrost control.

2.10 EXHAUST/RETURN SECTION

A. Provide on downflow units above 7 ½ tons, up to 75% exhaust air capabilities integral to unit at a 0.1" positive static pressure. Discharge dampers modulate exhaust air flow in response to

economizer outdoor air damper position.

2.11 OUTDOOR AIR SECTION

A. Provide a fully integrated factory installed 100% modulating outside air economizer with unit return and barometric relief air dampers. Unit operation is through primary temperature controls that automatically modulate dampers to maintain space temperature conditions.

B. Provide economizer with dry bulb control only.

C. Provide adjustable minimum position control located in the economizer section of the unit.

D. Provide spring return motor for outside air damper closure during unit shut down or power interruption.

2.12 OPERATING CONTROLS

A. Provide factory wired roof top units with 24 volt control circuit with control transformers, contactor pressure lugs for power wiring. Contractor to provide field installed unit mounted disconnect switch. Units shall have single point power connections. Field wiring of zone controls to be NEC Class II.

B. Provide microprocessor unit mounted control which when used with an electronic zone sensor provides proportional integral room control. This UCM shall perform all unit functions by making all heating, cooling and ventilating decisions through resident software logic.

C. Provide factory installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation (except 3-5 ton c/e and hp, accessory field installed).

D. For heat pump units provide a time initiated temperature terminated, electronic defrost control.

E. Provide the following factory installed and wired operating controls:

1. Provide a minimum three minute off timer to prevent compressor from short cycling.
2. Provide a time delay to sequence the starting of compressors.

2.13 STAGING CONTROLS

A. Provide NEC Class II, adjustable zone control to control heating stages in sequence with delay between stages and compressor stages and supply fan to maintain zone temperature setting.

1. Provide programmable electronic microcomputer based zone control.
2. Zone control shall incorporate:
    a. Automatic changeover from heating to cooling.
    b. Set-up for at least 2 - sets of separate heating and cooling temperatures per day.
    c. Instant override of setpoint for continuous or timed period from one hour to 31 days.
    d. Short cycle protection.
    e. Switch selection features including Fahrenheit display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.

3. Zone sensor display shall be capable of:
   a. Time of day.
   b. Actual room temperature.
   c. Programmed temperature.
   d. Programmed time.
   e. Duration of timed override.
   f. Day of week.
   g. System mode indication: heating, cooling, low battery fan on.

B. Provide mixed air sensor in supply air to close outside air damper.

2.14 BUILDING MANAGEMENT SYSTEM

A. Interface control module to Energy Management System to be furnished and mounted by rooftop unit manufacturer. Through this interface module, all Energy Management functions (specified in Energy Management Section) shall be performed. See building Automation and Automatic Temperature Control System Specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). If not furnished by rooftop unit manufacturer, this shall be furnished by Energy Management System Contractor for factory mounting by rooftop unit manufacturer in rooftop unit and rated for service up to 140 F. The only field connection to Energy Management System shall be a single communication link.

B. Control Functions: Include unit scheduling, occupied/unoccupied mode, start-up and coast-down modes, nighttime free-cool purge mode, demand limiting, night setback, discharge air set point adjustment, timed override and alarm shutdown.

C. Diagnostic Functions: Include supply fan status; cooling circuit status; a field supplied and installed sensor, to provide a dirty filter alarm; air flow failure; high temperature outdoor air sensor failure; compressor lockout; and if optional economizer is used, minimum position potentiometer failure.

D. Provide capabilities for Boolean Processing and trend logs as well as “templated” reports and logs.

2.15 UNIT PERFORMANCE REQUIREMENTS

A. Supply air fan performance data as submitted shall include the effect of a wet coil, downflow or horizontal configuration heat exchanger and the return air filter static loss.

B. Scheduled performance shall be based on ARI 210/240/340/360/ and ANSI Z21.47 test conditions.

2.16 ROOF CURB

A. Contractor shall provide factory supplied roof curb, 16 gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly.

B. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.

B. Contractor shall verify that proper power supply is available.

3.2 INSTALLATION

A. Contractor shall install in accordance with manufacturer's instructions.

B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

C. Provide start-up by factory trained and authorized personnel.

3.3 MANUFACTURER'S FIELD SERVICES

A. The manufacturer shall furnish an alternative price for:

1. Extended compressor warranty for five years.
2. Extended heat exchanger warranty for ten years.
3. Extended parts and labor by manufacturer to be provided to the owner for a period of five years.

B. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as acceptable for field maintenance and service.

END OF SECTION 237400

SECTION 237433 - PACKAGED, OUTDOOR, HEATING AND COOLING MAKEUP AIR-CONDITIONERS

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 cooling and heating rooftop units.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

1. Design Calculations: For selecting and designing restrained vibration isolation roof-curb rails.
2. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Rooftop units to roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Size and location of rooftop unit mounting rails and anchor points and methods for anchoring units to roof curb.
2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

D. Startup service reports.

E. Operation and Maintenance Data: For rooftop units to include in emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

G. LEED Submittals:

1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop units and are based on the specific system indicated. Refer to Division 01 Section "Product 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

A. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

B. Coordinate size, location, and installation of rooftop replacement-air unit manufacturer's roof curbs and equipment supports with roof Installer.

1. Coordinate installation of restrained vibration isolation roof-curb rails, which are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below 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 Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.

1.8 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.
2. Filters: One set for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. AAON.
2. Trane.
3. Daikin.
4. Reznor

2.2 CABINET

A. Exterior Casing: Galvanized steel with baked-enamel paint finish and with lifting lugs and knockouts for electrical and piping connections.

B. Interior Casing: Galvanized steel.

C. Base Rails: Galvanized-steel rails for mounting on roof curb.

D. Service Doors: Hinged access doors with neoprene gaskets.

E. Internal Insulation: Fibrous-glass duct lining complying with ASTM C 1071, Type II.

1. Thickness: 2 inches.
2. Insulation Adhesive: Comply with ASTM C 916, Type I.
3. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.

F. Condensate Drain Pans: Formed sections of stainless-steel sheet designed for self-drainage. Fabricate pans and drain connection to comply with ASHRAE 62.1-2004.

2.3 SUPPLY-AIR FAN

A. Fan: Forward-curved centrifugal; statically and dynamically balanced, galvanized steel, mounted on solid-steel shaft with self-aligning, permanently lubricated ball bearings.

B. Motor: Totally enclosed, single two-speed motor.

C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4 service factor.

D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with spring isolators.

2.4 REFRIGERATION SYSTEM

A. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

B. Compressors: Scroll compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater.

C. Minimum Efficiency: As defined by ASHRAE/IESNA 90.1-2004, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

D. Refrigerant: R-410A.

E. Refrigeration System Specialties:

1. Expansion valve with replaceable thermostatic element.
2. Refrigerant dryer.
3. High-pressure switch.
4. Low-pressure switch.
5. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
6. Brass service valves installed in discharge and liquid lines.
7. Operating charge of refrigerant.

F. Refrigerant Coils: Evaporator, condenser, and reheat condenser coils shall be designed, tested, fabricated, and rated according to ARI 410 and ASHRAE 33. Coils shall be leak tested under water with air at 315 psig.

1. Capacity Reduction: Circuit coils for interleaved control.
2. Tubes: Copper.
3. Fins: Aluminum.
4. Fin and Tube Joint: Mechanical bond.
5. Suction and Distributor: Seamless copper tube with brazed joints.
6. Coating: Phenolic epoxy corrosion-protection coating on both coils.
7. Source Quality Control: Test to 450 psig, and to 300 psig underwater.

G. Condenser Fan: Propeller type, directly driven by motor.

H. Safety Controls:

1. Compressor motor and outside-coil fan motor low ambient lockout.
2. Overcurrent protection for compressor motor and outside-coil fan motors.

2.5 INDIRECT-FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."

1. AGA Approval: Designed and certified by and bearing label of AGA.

B. Burners: Stainless steel.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark with flame sensor.

C. Heat-Exchanger Drain Pan: Stainless steel.

D. Venting: Gravity vented.

E. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.

F. Safety Controls:

1. Gas Control Valve: Electronic 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.

2.6 TOTAL ENERGY RECOVERY WHEEL SECTIONS

A. Total energy recovery wheels shall be provided as indicated on the schedule and drawings. Wheels shall be integral parts of the AHUs and shall be sized per the ventilation requirement of the units. Additional outside air units, or other field assembled and ducted energy recovery devices, are not acceptable. Mixed air units with economizing shall be constructed with internal bypass dampers such that the pressure drop across the wheel does not increase during economizing. External bypass and multiple duct connections are not acceptable.

B. The air handling unit shall be certified by AHRI to contain a rotary energy recovery wheel certified to ANSI/AHRI Standard 1060 and bears the AHRI 1060 label. The air handling unit and wheel must be AHRI 1060-certified as a package. Proof of compliance shall be that the air handling unit brand name and specific wheel being used be listed on the AHRI website within the Directory of Certified Product Performance for Commercial Air-to-Air Energy Recovery Ventilators under the Packaged Program Type. Verification of performance for non-AHRI 1060 certified AHU packages shall be completed by witness test for the owner/owner's representative and specifying engineer at the jobsite. Installing contractor shall be responsible for all expenses of verification testing, including test set-up, room/board for owner/owner's representative and engineer, travel to and from the jobsite, as well as modification costs associated to achieving specified performance.

C. Performance characteristics of the energy wheel shall be provided as defined by AHRI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard 1812.

D. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The total energy recovery wheel shall incorporate a desiccant without the use of binders or adhesives, which may plug the desiccant aperture. The adsorbent shall not be applied as a glued on surface coating and not susceptible to erosion, abrasion, or delamination. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable. Seals shall be factory set.

E. Wheel drive motor shall be provided mounted in the cassette frame. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioners. On units that require drive belt tensioners for the wheel belt/motor assembly, the unit manufacturer shall provide at no additional charge to the customer a visual inspection every four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings.

F. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

G. Access doors shall be provided for the removal of wheel segments. Doors shall be located on all air entering and air leaving sides of wheel to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal. Access doors shall be constructed per Section 2.04.

H. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity. Variable frequency speed control is not an acceptable method for controlling variable effectiveness.

I. Frost prevention shall be achieved by outside air bypass, return air preheat, or outside air preheat, depending upon design conditions. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Variable frequency speed control is not an acceptable method of frost control. Winter design supply and exhaust air

conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.

J. Control of energy wheels shall be incorporated and an integral part of the AHU control systems and shall be as described under the AHU control specifications. Secondary independent wheel controllers are not acceptable.

2.7 OUTDOOR-AIR INTAKE AND DAMPERS

A. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of 2000 fpm through damper and pressure differential of 4-inch wg.

B. Damper Operators: Electric.

C. Mixing Boxes: Parallel-blade, galvanized-steel dampers mechanically fastened to steel operating rod inside cabinet. Connect operating rods with common interconnecting linkages so dampers operate simultaneously.

D. Outdoor-Air Intake Hoods: Galvanized steel, with bird screen complying with ASHRAE 62.1-2004 and finish to match cabinet.

2.8 FILTERS

A. Comply with NFPA 90A.

B. Cleanable Filters: 2-inch-thick, cleanable metal mesh.

C. Disposable Panel Filters: 2-inch-thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames.

1. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
2. Frame: Galvanized steel.

2.9 CONTROLS

A. Control equipment and sequence of operation are specified in Division 23 Section "Instrumentation and Control for HVAC."

B. Factory-wire connection for controls' power supply.

C. Control devices, including sensors, transmitters, relays, switches, thermostats, humidistats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.

D. Unit Controls: Solid-state control board and components with field-adjustable control parameters.

E. Supply-Fan Control: Units shall be electrically interlocked with corresponding exhaust fans, to operate continuously when exhaust fans are running. Time clock shall switch operation from occupied to unoccupied. Night setback thermostat shall cycle fan during unoccupied periods to maintain space temperature.

1. Timer: Seven-day electronic clock.
2. Electrically interlock kitchen hood fire-extinguishing system to de-energize replacement-air unit when fire-extinguishing system discharges.

F. Unit-Mounted Status Panel:

1. Cooling/Off/Heating Controls: Control operational mode.
2. Damper Position: Indicates position of outdoor-air dampers in terms of percentage of outdoor air.
3. Status Lights:

    a. Filter dirty.
    b. Fan operating.
    c. Cooling operating.
    d. Heating operating.

G. Refrigeration System Controls:

1. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air or outdoor-air temperature is less than 60 deg F.
2. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F.
3. Wall-mounting, relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 60 percent.

H. Heating Controls:

1. Remote-mounting sensor for field installation in supply-air duct with sensor adjustment located in control panel modulates gas furnace burner to maintain space temperature.

I. Electric-Resistance Heating Controls: Wall-mounting thermostat sequences stages.

J. Damper Controls:

1. Wall-mounting pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space served by rooftop replacement-air unit at minimum 0.05-inch wg.

K. Integral Smoke Alarm: Smoke detector installed in supply and return air.

L. DDC Temperature Control: Stand-alone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC." Links shall include the following:

1. Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
2. Hardware interface or additional sensors for the following:

    a. Room temperature.
    b. Discharge air temperature.
    c. Refrigeration system operating.
    d. Furnace operating.

2.10 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation of rooftop replacement-air units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.

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

3.2 INSTALLATION

A. Install and secure rooftop replacement-air units on curbs and coordinate roof penetrations and flashing with roof construction.

B. Install wall- and duct-mounting sensors, thermostats, and humidistats furnished by manufacturers for field installation. Install control wiring and make final connections to control devices and unit control panel.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

1. Gas Burner Connections: Comply with requirements in Division 23 Section "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
2. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
3. Steam Coil Connections: Comply with requirements in Division 23 Section "Steam and Condensate Heating Piping." Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.

C. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to rooftop replacement-air units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to furnace combustion chamber.
2. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
3. Inspect casing insulation for integrity, moisture content, and adhesion.
4. Verify that clearances have been provided for servicing.
5. Verify that controls are connected and operable.
6. Verify that filters are installed.
7. Clean outside coil and inspect for construction debris.
8. Clean furnace flue and inspect for construction debris.
9. Inspect operation of power vents.
10. Purge gas line.
11. Inspect and adjust vibration isolators and seismic restraints.
12. Verify bearing lubrication.
13. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
14. Adjust fan belts to proper alignment and tension.
15. Start unit.
16. Start refrigeration system when outdoor-air temperature is within normal operating limits.

17. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
18. Operate unit for run-in period.
19. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

20. Calibrate thermostats.
21. Adjust and inspect high-temperature limits.
22. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
23. Start refrigeration system and measure and record the following:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

24. Verify operational sequence of controls.
25. Measure and record the following airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Outdoor-air intake volume.

26. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through outside coil or from outside coil to outdoor-air intake.

27. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-limit heat exchanger.
    b. Alarms.

C. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

D. Remove and replace components that do not pass tests and inspections and retest as specified above.

E. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop replacement-air units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 237433

SECTION 23 81 26 - SPLIT SYSTEM AIR CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Division 01 and Section 230502, BASIC MECHANICAL REQUIREMENTS

1.2 SUMMARY

A. General: Provide split air conditioning system complete, as shown and specified per Contract Documents, including, but not limited to, the following:

1. Outdoor mounted, air-cooled condensing unit.
2. Matching and corresponding indoor fan coil unit.
3. Refrigerant piping between indoor and outdoor units.
4. Control wiring between indoor and outdoor units.
5. Control.
6. Accessories.

B. Other Applicable Sections:

1. Applicable portions of Division 1 and Section 230502, BASIC MECHANICAL REQUIREMENTS and Section 230503, BASIC MECHANICAL MATERIALS AND METHODS, apply to the work of this Section.
2. Section 232113, HYDRONIC PIPING, Section 232300, REFRIGERANT PIPING and Section 230700, MECHANICAL INSULATION.

1.3 STANDARDS

A. Materials, equipment and installation shall comply with all applicable building laws and with published standards of:

1. ASHRAE
2. AMCA
3. ARI
4. U.L.
5. SMACNA

1.4 SUBMITTALS

A. Procedure: Refer to Division 1.

B. In addition to the requirements of Division 1 and of Section 23 05 02, BASIC MECHANICAL REQUIREMENTS, the submittal material shall include, but not be limited to, the following:

1. Descriptive Data:
   a. Performance data.

b. Published sound power levels based on actual test data.
c. Finishes.
d. Piping arrangement.
e. Accessories.
f. Condensing unit and fan coil unit operating weights.

2. Shop Drawings:
a. Installation details.
b. Wiring diagrams.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 01 Section "Product 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 07 Section "Roof Accessories."

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Daikin Applied

B. JCI

C. Mitsubishi

D. Sanyo

E. Trane

2.2 GENERAL

A. Manufacturers shall be responsible for examining application of each type of unit to assure that each will operate properly in the intended application.

B. Indoor and outdoor sections shall be of the same manufacturer.

C. Performance shall be as scheduled.

D. Combination of indoor and outdoor units shall be tested. "Approved Standard Ratings" shall be in accordance with Industry Standard 441-66.

2.3 OUTDOOR AIR-COOLED CONDENSING UNIT

A. General: Factory assembled, single piece, air-cooled condensing outdoor unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, compressor(s), full charge of R410A refrigerant, and special features required prior to field start-up.

B. Unit Cabinet:

1. Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a baked enamel finish.
2. Unit access panels shall be removable with mini-mal screws and shall provide full access to the compressor, fan, and control components.
3. Compressor compartment shall be isolated and have an acoustic lining to assure quiet operation.

C. Fans:

1. Condenser fans shall be direct-drive propeller type, shall discharge air horizontally or horizontally as indicated on drawing, and shall blow air through the condenser coil.
2. Condenser fan motors shall be totally enclosed, single phase motors with Class B insulation and permanently lubricated sleeve bearings. Motor shall be protected by internal thermal overload protection.
3. Shaft shall have inherent corrosion resistance.
4. Fan blades shall be corrosion resistant and shall be statically and dynamically balanced.
5. Condenser fan openings shall be equipped with PVC coated protection grille over fan and coil.

D. Compressor(s)

1. Compressor(s) shall be fully hermetic scroll type.

2. Compressors shall be equipped with oil system, operating oil charge, and motor internal overloads shall protect the compressors from over-temperature and overcurrent. Compressors shall also have high discharge gas temperature protection.
3. Motor shall be NEMA rated Class F, suitable for operation in a refrigerant atmosphere.
4. Compressor assembly shall be installed on rubber vibration isolators.
5. Compressors shall be single phase.

E. Condenser Coil: Coil shall be constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes which are cleaned, dehydrated and sealed.

F. Refrigeration Components: Refrigerant circuit components shall include brass external vapor supply line service valve(s), vapor return line service valve(s) with service gauge connection port, service gauge port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps, filter drier(s), pressure relief, liquid line solenoid valves, thermostatic expansion valves and a full charge of refrigerant.

G. Controls and Safeties: Operating controls and safeties shall be factory selected, assembled, and tested. Air Conditioning unit control shall be compatible and interfaced with the Building Control Systems, Section 230900, BUILDING AUTOMATION AND AUTOMATIC TEMPERATURE CONTROL SYSTEMS. The minimum control function shall include:

1. Controls:
   a. Time delay restart to prevent compressor reverse rotation.
   b. Automatic restart on power failure.
   c. Safety lockout if any condensing unit safety is open.
   d. A time delay control sequence through the fan coil board.
   e. High and low pressure switches.
   f. Automatic condenser fan motor protection.
2. Safeties:
   a. High condensing temperature protection (when matched with Carrier Model 40MVC fan coils).
   b. System diagnostics (when used with Carrier Model 40MVC fan coils).
   c. Compressor motor current and temperature overload protection.
   d. High pressure relief
   e. Condenser fan failure protection.

H. Electrical Requirements

1. Unit shall operate on single phase, 60 cycle power at 208/230V as specified on contract drawings.
2. Unit electrical power shall be a single point connection.
3. Unit or control voltage to the indoor fan coil shall be 24V.
4. All power and control wiring shall be installed per NEC and all local Building Codes.
5. Unit shall have low voltage terminal block connections.

I. Required Options:

1. Winter Start Control: Field installed winter start control shall permit start-up for cooling operation under low load conditions and at low ambient temperatures by bypassing the low pressure switch for a 3 minute delay period.

2. Low ambient controller shall be provide and installed on the unit.
3. Hot gas bypass.
4. Crankcase Heater: Field-installed crankcase heater shall be a clamp-on compressor oil sump heater. Heater shall be used in all applications where operation in cooling below 40°F outdoor ambient temperature is anticipated.

2.4 HIGH WALL FAN COIL UNIT

A. General: Indoor, direct-expansion, wall-mounted fan coil. Unit shall be complete with cooling coil, fan, fan motor, piping connectors, electrical controls, micro-processor control system, and integral temperature sensing. Unit shall be furnished with integral wall-mounting bracket, mounting hardware, thermistor interconnection cable, and condensate pump.

B. Cabinet: Cabinet discharge and inlet grilles shall be attractively styled, high-impact polystyrene. Cabinet shall be fully insulated for improved thermal and acoustic performance.

C. Fan Section: Fan shall be tangential direct-drive blower type with air intake at the upper front face of the unit and discharge at the bottom front. Automatic, motor-driven vertical air sweep shall be provided standard. Air sweep operation shall be user selectable. Horizontal direction may be manually adjusted (using remote controller) and vertical air sweep may be manually set.

D. Coil: Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins shall be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap and auxiliary drip pan under coil header.

E. Motor: Motors shall be open drip-proof, permanently lubricated ball bearing with inherent overload protection. Fan motors shall be 3-speed.

F. Filters: Unit shall have filter track with factory-supplied cleanable filters.

G. Controls: Controls shall consist of a microprocessor-based control system which shall control space temperature, determine optimum fan speed, and run self diagnostics. The temperature control range shall be from 64°F to 84°F.

H. Electrical Requirements: Unit shall operate on power supply as specified on the equipment schedule.

2.5 ACCESSORIES

A. Provide refrigerant piping filter/dryer and glass moisture indicator for Field Installation.

B. Provide system with “Long Refrigerant Line” package.

PART 3 - EXECUTION

3.1 GENERAL

A. Locate units as indicated on the Drawings. Contractor shall be responsible for verifying with the Owner's Representative if suitability is doubted and to notify the Owner's Representative before installation of any apparent improper installation.

3.2 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. 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.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according

3.4 REFRIGERANT PIPING

A. Refrigerant Piping: Conform to Section 232113, HYDRONIC PIPING and Section 232300, REFRIGERANT PIPING.

B. Coordinate with equipment manufacturer and provide necessary traps in refrigerant pipe as required.

3.5 EQUIPMENT AND PIPE VIBRATION ISOLATION [AND SEISMIC RESTRAINTS]

A. Conform to Section 230548, VIBRATION CONTROLS.

END OF SECTION 238126

SECTION 23 8216 - AIR COILS

PART 1 - GENERAL

1.1 SAFETY STANDARDS

A. Provide electric heating coil in compliance with the National Electric Code and listed by UL for zero clearance and so labeled.

1.2 CAPACITY RATINGS

A. Hydronic Coils: Certified per ARI 410.

1.3 SUBMITTALS

A. Submit manufacturer's product data including:

1. Performance data.
2. Accessories description
3. Operating weight.
4. Drawings showing:
   a. Dimensions.
   b. Sizes and locations of connections.
5. Support requirement.

1.4 FACE VELOCITY

Unless otherwise noted face velocities shall not exceed the following:

A. Cooling Coils: 550 fpm.

B. Heating Coils: 600 fpm. (except electric coils)

PART 2 - PRODUCTS

2.1 ELECTRIC HEATING COILS

A. Manufacturers:

1. Design Basis: Indeeco.
2. Other Acceptable Manufacturers:
   a. Trane.

B. Description:

1. Type: Finned tubular.
2. Mounting: Casing suitable for insertion between fan section and filter section of air handling unit furnished per Section 23 73 13 as shown on the drawings.

3. Controls:
    a. Provide factory mounted and wired control panel.
    b. Control Option: SCR
    c. Thermostat: Room
    d. Standard Features:
        1) Thermal Cutoffs.
        2) Airflow Switch.
        3) Magnetic Contactors.
        4) Control Transformer.
        5) Fuses.
    e. Optional Features:
        1) Disconnect Switch.
        2) Remote Panel.

2.2 HYDRONIC COILS

A. Manufacturers:

1. Design Basis: Trane
2. Other Acceptable Manufacturers:
    a. Aerofin
    b. Airtherm
    c. American Air Filter
    d. Bohn
    e. Carrier
    f. Colmac
    g. Dunham-Bush
    h. Daikin Applied
    i. Nationwide Coils
    j. USA Coil & Air
    k. York

2.3 HEATING COILS (Hot Water)

A. Construction:

1. Tubes: Copper.
2. Fins: Aluminum.
3. Casing: 16 gauge galvanized steel.
4. Max. service conditions:
    a. 200 psig.
    b. 220°
5. Certified in accordance with ARI Standard 410.

2.4 COOLING COILS (Chilled Water)

A. Construction:

1. Tubes: Copper.
2. Fins: Aluminum.

3. Casing: 16 gauge galvanized steel.
4. Max.service conditions:
   a. 200 psig.
   b. 220°
5. Certified in accordance with ARI Standard 410.

2.5 REFRIGERATION COILS

A. Designed to conform to ANSI-B9.1 Safety Code for mechanical refrigeration.

B. Tubes: Copper.

C. Fins: Aluminum.

D. Distributors: Equalizing Type.

E. Coils to be vertical split.

F. Accessories:

1. Distributor with hot gas bypass connection.
   a. Thermal expansion valve.
   b. Size per manufacturers requirements.
   c. Insulate sensing bulb.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install coils level and plumb.

B. Provide necessary auxiliary support.

C. Adjust air flow switch for safe operation.

D. Check and adjust all controls.

E. Pipe condensate drain from cooling coils as shown on the drawings or to nearest floor drain or mop sink.

F. Coordinate electrical requirements with Division 16 prior to ordering. Report any discrepancies to the Engineer for resolution.

END OF SECTION 238216

SECTION 23 8239 - HEATING TERMINAL UNITS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's product data:

1. Performance data.
2. Drawings.
   a. Dimensions
   b. Support requirements
   c. Size and location of connections
3. Enclosure gauges.
4. Accessories.
5. Parts lists.
6. Additional Submittal Requirements for Fan Coil Units, Cabinet Heaters and Unit Heaters:
   a. Wiring diagrams.
   b. Installation, operating and maintenance instructions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide manufacturer's standard products as indicated by published product information, and as required for a complete installation.

2.2 ELECTRIC UNIT HEATERS

A. Manufacturers:

1. Design Basis: Modine.
2. Other Acceptable Manufacturers:
   a. American Air Filter
   b. Daikin Applied
   c. Trane

B. Construction:

1. Casing:
   a. Material: Steel.
   b. Finish: Baked-on enamel.
   c. Heating Element Supports: Adjustable.
   d. Gaskets: Between front panel and enclosure.
2. Grilles: Louver: Adjustable.
3. Heating Element: Finned steel sheaths providing extended surface.

4. Provide manufacturer's written certification that unit is suitable for use at altitude of the project.

2.3 UNIT HEATERS

A. Manufacturers:
   1. Design Basis: Trane
   2. Other acceptable manufacturers: shall meet this specification.

B. Construction:

   1. Casing:
      a. Material: steel.
      b. Finish: baked-on enamel.
      c. Gaskets: between front panel and enclosure.
   2. Grilles: louvered: adjustable.
   3. Coils:
      a. Fins: aluminum.
      b. Tubes: copper, expanded into fins.
      c. Working pressure: 250 psi.

PART 3 - EXECUTION

3.1 GENERAL

A. Locate units so clearance is provided for:

   1. Service and maintenance.
   2. Enclosure removal.

B. Level or pitch elements as required:

   1. Install shims if necessary.

C. Touch-up finish after final adjustment.

D. Replace damaged enclosures.

E. Straighten bent fins.

F. Replace damaged elements.

END OF SECTION 238239

SECTION 23 9000 - PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:

1. Copies of all warranties
2. Operation & Maintenance Manuals
3. Required tests
4. Test and balance reports
5. Record drawings
6. Permit requirements
7. Valve tag list

B. The contractor shall compile a closeout manual which shall include:

1. A list of all required tests and a place for signoff of date completed.
2. A list of all submittals with dates of acceptance by the engineer.
3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
4. Test procedures to be used for life safety systems.
5. Project close out check list.

C. The final closeout manual shall include the following:

1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, architect, building official, etc.).
2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
3. Copies of all warranties.
4. Test and Balance report.

D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

1.2 SUBMITTALS

A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:

1. A list of all required tests.
2. Preliminary schedule showing major milestones for completion of the mechanical/plumbing systems.

B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

C. Within 2 weeks of substantial completion submit a completed "Project Closeout Check List", and the Final Closeout Manual.

D. Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.

Project Close-Out Summary – Mechanical, Plumbing and Fire Protection

☐ All required submittals have been cleaned, submitted and either been approved or modified in accordance with the Engineer's "make corrections noted" comments. Our records indicate the following submittals are still outstanding:

☐ Clean filters installed in all units. (Install just prior to building turnover)

☐ All equipment has been started up and is functioning within manufacturers' recommendations without any undue noise or vibration. (Submit a list of equipment with startup dates. Provide list no later than 120 days prior to project completion date).

☐ All vibration isolation has been installed and is operating properly.

☐ Duct access doors have been installed at fire and fire/smoke dampers and are properly fire-stopped and fire and fire/smoke dampers have been visually inspected to confirm that they are open.

☐ Access doors have been installed as required for concealed equipment, water hammer arrestors, valves, controls, actuators, etc.

☐ Chemical treatment system installed per specification and functioning properly.

☐ All equipment has been installed with the manufacturers recommended service clearances and is fully accessible for required maintenance.

☐ All equipment and piping is labeled per specifications.

☐ All hydronic, gas and plumbing piping cleaned, flushed and tested per specifications. Submit testing reports for record. Submit letter stating domestic water disinfection (chlorination) has been completed per the specifications.

☐ All action items are complete as listed in the action items reports. Submit a list of action items with sign off by Architect or Engineer for record. Punch list to be completed prior to turn over of building.

☐ Smoke control system tested and accepted by local authorities (in accordance with specifications). Submit dates for testing along with proposed test procedures.

☐ Temperature control system complete and tested per specifications.

- ☐ Test and balance complete and report submitted and accepted by Engineer.
- ☐ Domestic water booster pump and sanitary waste system tested and functional (Super Flush).
- ☐ Fire sprinkler system and pump tested per specifications.
- ☐ Operation and maintenance manuals submitted with table of contents and required documentation for extended warranties.
- ☐ Factory Testing documented and submitted for record.
- ☐ Record drawings submitted per specifications.
- ☐ Temperature Control record documents provided per specifications.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, architect, and building official).

3.2 LIFE SAFETY SYSTEMS

A. All life safety systems shall be fully and successfully tested by the contractor before being witnessed by the engineer or building official

B. The contractor shall provide a detailed test procedure, with instrumentation to be used, for approval by the engineer and building official prior to any testing.

C. Once tested by the contractor and fully operational, the systems shall be demonstrated to the engineer. Once accepted by the engineer the system shall be demonstrated to the building and fire officials.

3.3 COORDINATION WITH OTHERS

A. The Division 21 through 23 contractor shall coordinate his requirements with the General Contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 21 through 23 systems.

3.4 PUNCH LISTS

A. The contractor shall submit in writing that the project is ready for final review by the engineer.

B. Once the project is ready for final review the engineer will create a punch list of any corrections or deficiencies.

C. The contractor shall complete all punch list items and provide a letter to the architect after completion stating all items have been completed or reasons why they were not completed.

D. Upon receipt of this letter the engineer will verify that the punch list has been satisfactorily completed.

END OF SECTION 239000

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
2. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Alcan Products Corporation; Alcan Cable Division.
2. Alpha Wire.
3. Belden Inc.
4. Encore Wire Corporation.
5. General Cable Technologies Corporation.
6. Southwire Incorporated.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2.

D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. AFC Cable Systems, Inc.
2. Gardner Bender.
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. Ilsco; a branch of Bardes Corporation.
6. NSi Industries LLC.
7. O-Z/Gedney; a brand of the EGS Electrical Group.
8. 3M; Electrical Markets Division.
9. Tyco Electronics.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

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

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

G. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

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

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

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

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements.

    a. Switchboard.
    b. Panelboards.
    c. HVAC more than 10 ton.
    d. Generator.
    e. ATS Switch.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 26 0523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Multimode optical-fiber cabling.
2. Low-voltage control cabling.
3. Control-circuit conductors.
4. Identification products.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

D. RCDD: Registered Communications Distribution Designer.

E. UTP: Unshielded twisted pair.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

2.2 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

2.3 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat paint. Comply with requirements in Section 099123 "Interior Painting."

2.4 OPTICAL-FIBER CABLE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Belden Inc.
2. CommScope, Inc.
3. Corning Incorporated.
4. Emerson Connectivity Solutions.
5. General Cable Technologies Corporation.
6. Mohawk; a division of Belden Inc.

7. Nexans; Berk-Tek Products.
8. Siemon Company (The).
9. Superior Essex Inc.
10. SYSTIMAX Solutions; a CommScope, Inc. brand.
11. 3M.
12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: Multimode, 50/125-micrometer, 24-fiber, nonconductive, tight-buffer, optical-fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA-B for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

    a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    b. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
    c. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
    d. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
    e. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
    f. Riser Rated, Conductive: Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.
    g. General Purpose, Conductive: Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

5. Conductive cable shall be steel-armored type.
6. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Aqua for 50/125-micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.5 OPTICAL-FIBER CABLE HARDWARE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. ADC.

2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Corning Incorporated.
5. Dynacom Inc.
6. Hubbell Incorporated.
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Company (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA-568-C.3.
2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss of not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.6 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. Multi-pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.7 CONTROL-CIRCUIT CONDUCTORS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Encore Wire Corporation.
2. General Cable Technologies Corporation.
3. Southwire Company.

B. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.

C. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 44.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Smoke control signaling and control circuits.

2.8 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables according to TIA-568-C.2.

C. Factory test optical-fiber cables according to TIA-568-C.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
2. Outlet boxes for optical-fiber cables shall be no smaller than 4 inches square by 1-1/2 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced.
5. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lay on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Optical-Fiber Cable Installation:

1. Comply with TIA-568-C.3.
2. Terminate cable on connecting hardware that is rack or cabinet mounted.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.

2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
   b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches.

3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

   a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches.
   c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches.

4. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
5. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.

2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visually inspect and optical-fiber cable jacket materials for UL or third-party certification markings.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical-Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

b. Link End-to-End Attenuation Tests:

1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
2) Attenuation test results for links shall be less than 2.0 dB.

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: 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. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.

        1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
        2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Dossert; AFL Telecommunications LLC.
3. ERICO International Corporation.
4. Fushi Copperweld Inc.
5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning and Grounding.

2.2 SYSTEM DESCRIPTION

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 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 and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: steel; 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install barecopper conductor, No. 4/0 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. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, 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; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

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

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

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

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. 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. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

C. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical

service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Installbonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

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

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

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

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

END OF SECTION 260526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

    a. Hangers.
    b. Steel slotted support systems.
    c. Nonmetallic support systems.
    d. Trapeze hangers.
    e. Clamps.
    f. Turnbuckles.
    g. Sockets.
    h. Eye nuts.
    i. Saddles.
    j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.

3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Projectors.

B. Seismic Qualification Certificates: For hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
1. Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Atkore International.
g. Wesanco, Inc.

2. Material: Galvanized steel.
3. Channel Width: 1-5/8 inches.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
8. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Subject to compliance with requirements, provide products by one of the following:

      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Subject to compliance with requirements, provide products by one of the following:

      1) Cooper B-Line, Inc.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

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

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

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION 260529

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways and for each color and texture specified, 12 inches long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal 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.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Anamet Electrical, Inc.
4. Electri-Flex Company.
5. O-Z/Gedney.

6. Picoma Industries.
7. Republic Conduit.
8. Robroy Industries.
9. Southwire Company.
10. Thomas & Betts Corporation.
11. Western Tube and Conduit Corporation.
12. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. FMC: Comply with UL 1; zinc-coated steel.

I. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

J. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

    a. Material: Steel or die cast.
    b. Type: compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

K. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corporation.
6. Condux International, Inc.
7. Electri-Flex Company.
8. Kraloy.
9. Lamson & Sessions; Carlon Electrical Products.
10. Niedax-Kleinhuis USA, Inc.
11. RACO; Hubbell.
12. Thomas & Betts Corporation.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Rigid HDPE: Comply with UL 651A.

G. Continuous HDPE: Comply with UL 651B.

H. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

I. RTRC: Comply with UL 1684A and NEMA TC 14.

J. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

K. Fittings for LFNC: Comply with UL 514B.

L. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

M. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Mono-Systems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.

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

a. Mono-Systems, Inc.
b. Panduit Corp.
c. Wiremold / Legrand.

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

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

a. Hubbell Incorporated.
b. Mono-Systems, Inc.

c. Panduit Corp.
d. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman.
7. Hubbell Incorporated.
8. Kraloy.
9. Milbank Manufacturing Co.
10. Mono-Systems, Inc.
11. O-Z/Gedney.
12. RACO; Hubbell.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

I. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

J. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

K. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

L. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

M. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

N. Gangable boxes are prohibited.

O. Hinged-Cover Enclosures: Comply with UL 50 and 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. Nonmetallic Enclosures: Fiberglass.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

P. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
   1. Subject to compliance with requirements, provide a comparable product by one of the following:

      a. Armorcast Products Company.
      b. Carson Industries LLC.
      c. NewBasis.
      d. Oldcastle Precast, Inc.
      e. Quazite: Hubbell Power System, Inc.
      f. Synertech Moulded Products.
   2. Standard: Comply with SCTE 77.
   3. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
   4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
   5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   6. Cover Legend: Molded lettering, "ELECTRIC.".
   7. Conduit Entrance Provisions: Conduit-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: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.
   1. Subject to compliance with requirements, provide a comparable product by one of the following:

      a. Armorcast Products Company.
      b. Carson Industries LLC.
      c. NewBasis.
      d. Nordic Fiberglass, Inc.
      e. Oldcastle Precast, Inc; Christy Concrete Products.
      f. Quazite: Hubbell Power System, Inc; Hubbell Power Systems.
      g. Synertech Moulded Products.
   2. Standard: Comply with SCTE 77.
   3. Color of Frame and Cover: Gray.
   4. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
   5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
   6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   7. Cover Legend: Molded lettering, "ELECTRIC.".
   8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

9. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: IMC.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Gymnasiums.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inchesof enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to GRC before rising above floor.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. 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.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. 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. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inchradius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section.

Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center top bottom of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.

b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level 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: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line, 24″ below grade.

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. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for 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.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

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

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.

1.3 DEFINITIONS

A. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for handholes, boxes, and other utility structures.
4. Include warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
f. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

C. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Comply with ANSI C2.

2.2 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Spiraduct/AFC Cable Systems, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.

2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.

    a. Color: Red dye added to concrete during batching.
    b. Mark each plank with "ELECTRIC" in 2-inch- high, 3/8-inch- deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast Group.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile Inc.

B. Comply with ASTM C 858 for design and manufacturing processes.

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 box.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing 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 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."
7. Configuration: Units shall be designed for flush burial and have closed 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 12 inches.
b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

9. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
10. 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. 3 steel reinforcing bars in concrete around each opening.

11. Duct Entrances in Handhole Walls: 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.

12. 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.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have integral closed 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, "ELECTRIC."
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected 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 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.
   1. Subject to compliance with requirements, provide a comparable product by one of the following:

      a. Armorcast Products Company.
      b. Carson Industries LLC.
      c. NewBasis.
      d. Quazite: Hubbell Power System, Inc

2.6 PRECAST MANHOLES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

   1. Christy Concrete Products.
   2. Elmhurst-Chicago Stone Co.
   3. Oldcastle Precast Group.
   4. Rinker Group, Ltd.
   5. Riverton Concrete Products.
   6. Utility Concrete Products, LLC.
   7. Utility Vault Co.
   8. Wausau Tile Inc.

B. Comply with ASTM C 858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

E. 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.

   1. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
   2. 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.
   3. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

   1. Type and size shall match fittings to duct or conduit to be terminated.
   2. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.

G. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

H. Ground Rod Sleeve: Provide a 3-inch PVC conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths Driveways and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 structural load rating.
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: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation, and re-establish 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 topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT INSTALLATION

A. Install ducts according to NEMA TCB 2.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.

C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

F. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet 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 in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

G. 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.

H. Pulling Cord: Install 100-lbf- test nylon cord in empty ducts.

I. Concrete-Encased Ducts: Support ducts on duct separators.

1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct bank on each side.
3. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
4. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
5. Separator Installation: 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 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.
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. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

    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.

8. 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.
9. 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.
10. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 2 inches on each side of duct bank.
11. Concreting Sequence: Pour each run of envelope between manholes or other 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 a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

12. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place 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. 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.

J. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than five 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.
4. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Elbows: Install manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

    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.

9. 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. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

   a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.
   b. Place minimum 6 inches of engineered fill above concrete encasement of duct bank.

K. 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 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.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND 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. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below frost line, 24˝ below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 071354 "Thermoplastic Sheet Waterproofing." After ducts have been connected and grouted, and before

backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

E. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

F. Field-Installed Bolting Anchors in Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level 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: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below frost line, 24″ below grade.

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. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in 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.

G. For enclosures installed in asphalt paving and concrete and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch- long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

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.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

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

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. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

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

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

    a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Subject to compliance with requirements, provide a comparable product by one of the following:

    a. Advance Products & Systems, Inc.
    b. CALPICO, Inc.
    c. Metraflex Company (The).
    d. Pipeline Seal and Insulator, Inc.
    e. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
   1. Subject to compliance with requirements, provide a comparable product by one of the following:

      a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

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

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

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
   2. Sealant shall have VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

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

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

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

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

C. Self-Adhesive Labels:

1. Preprinted, 3-mil- thick, polyester flexible label with acrylic pressure-sensitive adhesive.

a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable diameter, such that the clear shield overlaps the entire printed legend.

2. Polyester, thermal, transfer-printed, 3-mil- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

a. Nominal Size: 3.5-by-5-inch.

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

2.4 BANDS AND TUBES:

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

2.5 TAPES AND STENCILS:

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch- wide black stripes on 10-inch centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

D. Floor Marking Tape: 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

E. Underground-Line Warning Tape

1. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

3. Tag: Type II:

a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches.
c. Thickness: 12 mils.
d. Weight: 36.1 lb/1000 sq. ft..
e. Tensile according to ASTM D 882: 400 lbf and 11,500 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 Tags

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

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.

C. Write-On Tags:

1. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

    a. For signs up to 20 sq. inches, minimum 1/16-inch-.
    b. For signs larger than 20 sq. inches, 1/8 inch thick.
    c. Engraved legend with black letters on white face.
    d. Punched or drilled for mechanical fasteners.
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. 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.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. 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.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

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 stripes to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: labels. Install labels at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 10-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.

b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. 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.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags.

G. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive, self-laminating polyester labels with the conductor designation.

J. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

M. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless

otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. 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 unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
    b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
    c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
    d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchboards.
e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
f. Emergency system boxes and enclosures.
g. Enclosed switches.
h. Enclosed circuit breakers.
i. Enclosed controllers.
j. Variable-speed controllers.
k. Push-button stations.
l. Power-transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Power-generating units.
p. Monitoring and control equipment.
q. Receptacle outlets (Circuit Nos.).
r. Data Outlets (Port Nos.).
s. Fusible Disconnect Switches.
t. Junction Boxes (Circuit Nos.).

END OF SECTION 260553

SECTION 26 0572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

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 a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.
2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary

submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Software Developer.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Subject to compliance with requirements, available software developers offering software that may be used for the Work include, but are not limited to, the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.

d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Calculated asymmetrical fault currents:

      1) Based on fault-point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.
      3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
   g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. Forequipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent

with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchboard.
3. Motor-control centers.
4. Control panels.
5. Standby generators and automatic transfer switches.
6. Branch circuit panelboards.
7. Disconnect switches.

3.3 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 260572

SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

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 computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Software Developer.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.
2) Protective device coordination study.
3) Time-current coordination curves.

b. Power system data.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

B. Subject to compliance with requirements, available software developers offering software that may be used for the Work include, but are not limited to, the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

C. Comply with IEEE 242 and IEEE 399.

D. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

E. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.

2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchboard, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.
        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.
    b. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.

c. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
d. Cables and conductors damage curves.
e. Ground-fault protective devices.
f. Motor-starting characteristics and motor damage points.
g. Generator short-circuit decrement curve and generator damage point.
h. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchboard.
3. Standby generators and automatic transfer switches.
4. Branch circuit panelboards.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.

2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.4 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141,, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
15. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 260573

SECTION 26 0574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

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 a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary

submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Software Developer.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

B. Subject to compliance with requirements, available software developers offering software that may be used for the Work include, but are not limited to, the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

C. Comply with IEEE 1584 and NFPA 70E.

D. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

G. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Motor horsepower and NEMA MG 1 code letter designation.

13. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Switchboard.
2. Control panel.
3. Panelboards.
4. Fusible Disconnect Switches.
5. Generator.
6. ATS Switches.
7. Pull Boxes.
8. Motors (1 HP or larger).

3.5 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION 260574

SECTION 26 0923 - LIGHTING CONTROL DEVICES

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. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching controls.
4. Indoor occupancy sensors.
5. Outdoor motion sensors.
6. Lighting contactors.
7. Emergency shunt relays.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Invensys Controls.
4. Leviton Manufacturing Co., Inc.
5. NSi Industries LLC; TORK Products.
6. Tyco Electronics; ALR Brand.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST.
3. Contact Rating: 20-A ballast load, 120-/240-V ac.
4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
6. Astronomic Time: All channels.
7. Automatic daylight savings time changeover.
8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

C. Electromechanical-Dial Time Switches: Comply with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST.
3. Contact Rating: 20-A ballast load, 120-/240-V ac.
4. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
5. Astronomic time dial.
6. Eight-Day Program: Uniquely programmable for each weekday and holidays.
7. Skip-a-day mode.
8. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. NSi Industries LLC; TORK Products.
4. Tyco Electronics; ALR Brand.

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, 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, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

C. Description: Solid state, with SPST dry contacts rated for 1800 VA, to operate connected load, complying with UL 773.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Lightning Arrester: Air-gap type.
5. Mounting: Twist lock complying with NEMA C136.10, with base.

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Cooper Industries, Inc.
2. Eaton Corporation.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. NSi Industries LLC; TORK Products.
7. Sensor Switch, Inc.
8. Tyco Electronics; ALR Brand.
9. Watt Stopper.

B. 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. System programming is done with two hand-held, remote-control tools.

    a. Initial setup tool.
    b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate electronic dimming ballasts. Sensor is powered by controller unit.
3. Power Pack: Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
4. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

2.4 INDOOR OCCUPANCY SENSORS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lightolier Controls.
6. Lithonia Lighting; Acuity Brands Lighting, Inc.
7. Lutron Electronics Co., Inc.
8. NSi Industries LLC; TORK Products.
9. RAB Lighting.
10. Sensor Switch, Inc.
11. Square D.
12. Watt Stopper.

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 15 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.

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 sq. in..
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. 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.

D. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy .

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 inches/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. 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.

E. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lightolier Controls.
6. Lithonia Lighting; Acuity Brands Lighting, Inc.
7. Lutron Electronics Co., Inc.
8. NSi Industries LLC; TORK Products.
9. RAB Lighting.
10. Sensor Switch, Inc.
11. Square D.
12. Watt Stopper.

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, and shall comply with California Title 24.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP.
4. Voltage: Match the circuit voltage; type.
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 at up to 30 minutes.
7. Concealed "off" time-delay selector at 30 seconds, and 5, 10, and 20 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

D. Wall-Switch Sensor Tag WS2:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: PIR.

3. Switch Type: SP.
4. Voltage: Match the circuit voltage; type.
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 at up to 30 minutes.
7. Concealed "off" time-delay selector at 30 seconds, and 5, 10, and 20 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

2.6 HIGH-BAY OCCUPANCY SENSORS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Hubbell Building Automation, 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 half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
4. Operating Ambient Conditions: 32 to 149 deg F.
5. Mounting: Threaded pipe.
6. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
7. Detector Technology: PIR.
8. Power and dimming control from the lighting fixture ballast that has been modified to include the dimming capacitor and MyzerPORT option.

C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet.

D. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

2.7 EXTREME-TEMPERATURE OCCUPANCY SENSORS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Cooper Industries, Inc.
2. Sensor Switch, Inc.

B. Description: Ceiling-mounted, solid-state, extreme-temperature 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 application in damp locations.
2. Operation: 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. Operating Ambient Conditions: From minus 40 to plus 125 deg F.
4. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
5. 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.
6. 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 cover.

7. Bypass Switch: Override the "on" function in case of sensor failure.
8. Automatic Light-Level Sensor: Adjustable from 2 to 10 fc; keep lighting off when selected lighting level is present.

C. Detector Technology: PIR. Ceiling mounted; detect occupants in coverage area by their heat and movement.

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 sq. in..
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1500 sq. ft. when mounted on a 96-inch- high ceiling.
3. Detection Coverage (High Bay): Detect occupancy within 25 feet when mounted on a 25-foot- high ceiling.

2.8 LIGHTING CONTACTORS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP.
3. Eaton Corporation.
4. General Electric Company; GE Consumer & Industrial - Electrical Distribution; Total Lighting Control.
5. Square D.

B. Description: Electrically operated and electrically held, combination-type lighting contactors with fusible switch, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

C. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.

1. Monitoring: On-off status, all points as described on drawings.
2. Control: On-off operation, all points as described on drawings.

2.9 EMERGENCY SHUNT RELAY

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Lighting Control and Design.
2. Watt Stopper.

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: 120 V.

2.10 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 260519 "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 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller thanNo. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 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.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "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. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Lighting control devices will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 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. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.7 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.13 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 26 0926 - LIGHTING CONTROL PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Lighting controls using electrically operated circuit breakers.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for field-mounted photoelectric switches, occupancy sensors, and motion sensors.
2. Section 260933 "Central Dimming Controls" for daylight harvesting control components.
3. Section 260936.19 "Standalone Multipreset Modular Dimming Controls" for daylight harvesting control components.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. IP: Internet protocol.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

E. PC: Personal computer; sometimes plural as "PCs."

F. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

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 control modules, power distribution components, manual switches and plates, and conductors and cables.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each lighting control panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
7. Include diagrams for power, signal, and control wiring.
8. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.

1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the network protocol.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For panelboards, 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.

D. Field quality-control reports.

E. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

F. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Printout of software application and graphic screens.
4. Device address list.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Electrically Operated, Molded-Case Circuit Breakers: Equal to 100 percent of amount installed for each size indicated, but no fewer than 20.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NECA 407.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton Corporation; Pow-R-Command Lighting Control Panelboards.
2. General Electric Company; A-Series Lighting Control Panels.
3. Lithonia Lighting; Acuity Brands Lighting, Inc; SmartBreaker Panels.
4. Siemens Energy & Automation, Inc; i-3 Lighting Controls.
5. Square D; PowerLink G3 Lighting Control Panelboards.

B. Source Limitations: Obtain lighting controls and power distribution components from single manufacturer.

2.2 SYSTEM DESCRIPTION

A. Input signal from field-mounted or on-board signal source shall open or close one or more electrically operated circuit breakers in the lighting control panelboards. Any combination of inputs shall be programmable to any combination outputs.

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

C. Comply with 47 CFR, Subpart A and Subpart B, for Class A digital devices.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

B. Expansion Requirements: Capacity for future expansion of number of control functions by 25 percent of current capacity; to include equipment ratings, housing capacities, spare spaces for circuit breakers, terminals, number of conductors in control cables, and control software.

C. Interface with DDC System for HVAC: Provide hardware and software to enable the DDC system for HVAC to monitor, control, display, and record data for use in processing reports.

1. Hardwired Points:

a. Monitoring: On-off status, all points as described in drawings.
b. Control: On-off operation, all points as described in drawings.

2. Communication Interface: Comply with ASHRAE 135. The communication interface shall enable the DDC system for HVAC operator to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.4 PANELBOARDS

A. The lighting panelboards may contain remotely operated circuit breakers and standard branch circuit breakers specified in Section 262416 "Panelboards."

B. Assemblies: Comply with UL 67 and NEMA PB 1.

C. Surge Protective Device: Field mounted, complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

D. Surge Protective Device: Integrally mounted, complying with UL 1449 Type 1.

1. Comply with IEEE C62.41, Category C, 200-kA short-circuit current rating.
2. Non-modular type with the following features and accessories:

    a. Digital-display indicator lights for power and protection status.

E. Enclosures: Comply with UL 50 and NEMA 250.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt 10-kA symmetrical short-circuit current available at terminals.

H. Panelboards shall have a UL-listed interrupting rating of 10 kA, sufficient for the application, or a UL-listed, series-connected rating for the maximum available fault current at that point in the system.

2.5 CIRCUIT BREAKERS

A. Remotely operated branch circuit breakers used for lighting control shall provide branch-circuit overcurrent protection.

B. Labeled with SWD and HID Ratings: Comply with UL 489 for 15- and 20-A, single-pole branch devices. 15- and 20-A circuit breakers, if scheduled, shall be a product of the same manufacturer and be of the same class as the rated circuit breakers.

C. Switching Endurance Rating: Not less than 200,000 full-load open/close/open remote operations.

D. Remotely Operated Circuit Breakers: Manual override switch or handle position shall enable or disable the remote operation of the device and allow breaker handle to manually control the breaker's on-off status.

2.6 MAIN CONTROLLERS

A. Description: Controllers shall contain the power supply and electronic control for operating and monitoring remotely operated branch circuit breakers.

1. Comply with UL 916; with a microprocessor-based, solid-state, 365-day timing and control unit.
2. Power Supply: Powered from the panelboard, sized to provide control power for the operation of the remotely operated circuit breakers, controller, bus system, low-voltage inputs, field-installed occupancy sensors, and low-voltage photo sensors.
3. Integral keypad and digital-display front panel for local setup, including the following:

    a. Blink notice, time adjustable from software.
    b. Ability to log and display remotely operated breaker on-time.
    c. Capability for accepting downloadable firmware so that the latest production features may be added in the future without replacing the module.

4. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation.
5. Ethernet Communications: Comply with ASHRAE 135 protocols.

    a. Each input connected to the controller shall control any remotely operated breaker in any other networked lighting control panel.
    b. A schedule programmed at one controller shall be able to control any remotely operated breaker in any other networked lighting control panel.

6. Time Synchronization: The timing unit shall be updated not less than every 24 hour(s) with the network time server.
7. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard Web browser.

    a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
    b. Separate Web page, showing status of each main and slave lighting control panel with the arrangement of breakers on the page matching the physical appearance of the panel. Status shall include breaker nametags, pole configuration, location in panel, actual contact state (on-off/tripped/manual), and breaker on-time and blink information in real time.
    c. Panel summary showing the master and slave panels connected to the controller.
    d. Controller diagnostic information.
    e. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens shall also allow direct breaker control and zone overrides.

8. Alarm and E-mail Notification: Automatically initiate alarms based on preconfigured conditions listed below and routing alarm alerts as set at the control panel.

    a. General Alarms: Power loss, non-responding breakers, loss and restoration of sub-net communications, loss and restoration of serial port communications, loss and restoration of DDC system for HVAC commands.
    b. Specific Alarms: Input status, zone status, breaker status on-time (0 to 99999 hours).
    c. E-mail Notification: Automatically route e-mail messages to five individual e-mail addresses. Within the body text of the e-mail, include a link that automatically redirects the user to the associated panels' status Web page.

B. Timing Unit:

1. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
2. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
3. 16 independent schedules, each having 24 time periods.
4. Schedule periods settable to the minute.
5. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
6. 32 special date periods.

C. With 16 inputs, each configurable to the following parameters:

1. Normally open, normally closed, two-wire maintained toggle, two-wire momentary toggle, two-wire momentary on, two-wire momentary off, or three-wire momentary operation.
2. On and off-delay timers for local override operation, adjustable from five minutes to 12 hours. Local override shall be by field-installed, two-wire momentary toggle switch.

2.7 SLAVE PANEL CONTROLLERS

A. Slave panels shall contain the necessary busses and network hardware to allow connection of the sub-net wiring between panels, with programming at the main panel controller. Programmable timing unit, Web server, alarm and e-mail notification, and Ethernet connection to the control network is not required provided all of these functions are available for the slave panel from the main lighting panel controller.

B. Sub-net wiring connections shall allow connection of wiring to a terminal that can be removed from the panel without interrupting communications to other panels.

C. Slave panels shall contain a nameplate label attached to the deadfront trim indicating the panel designation, panel network address, and panel designation of the associated master panel.

2.8 CONTROL NETWORK

A. Panel Controllers: Networked with other lighting control system controllers in a peer-to-peer configuration using Ethernet 100Base-T network.

B. Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via DDC system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.9 MANUAL SWITCHES AND PLATES

A. Keypads: Programmable, designed to control lighting applications and functions associated with the equipment of this Section. The units shall be able to control any system output device, including remotely operated circuit breakers, relays, dimmers, and analog outputs.

B. Push-Button Switches: Modular, momentary-contact, low-voltage type.

1. Match color specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

C. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 262726 "Wiring Devices."

D. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."

E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.10 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 and Class 3 Control Cables: Multiconductor cable with copper conductors not smaller thanNo. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e for horizontal copper cable. Comply with requirements in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 PANELBOARD INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NECA 407.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Mounting Height: 90 inches to top of trim above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

F. Install filler plates in unused spaces.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate loads served by each circuit; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are unacceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Panelboard will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Confirm correct communication wiring, initiate communications between panels, and program the lighting control system according to approved zone configuration schedules, time-of-day schedules, and input override assignments.

3.7 ADJUSTING

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

3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control modules.

END OF SECTION 260926

SECTION 26 0933 - CENTRAL DIMMING CONTROLS

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 microprocessor-based central dimming controls with the following components:

1. Digital control network.
2. Master-control stations.
3. Partitioned-space master-control stations.
4. Wall stations.
5. Dimmer cabinets.
6. Manual switches and plates for controlling dimmers.

1.3 DEFINITIONS

A. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.

B. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

C. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.

D. Low Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.

E. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

F. SCR: Silicon-controlled rectifier.

G. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For central dimming controls; include elevation, features, characteristics, and labels.
2. For dimmer panels; include dimensions, features, dimmer characteristics, ratings, and directories.
3. Device plates, plate color, and material.
4. Ballasts and lamp combinations compatible with dimmer controls.
5. Sound data including results of operational tests of central dimming controls.
6. Operational documentation for software and firmware.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.

D. Samples for Verification: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For central dimming controls with remote-mounting dimmers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Software manuals.
b. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
c. Operation of adjustable zone controls.
d. Testing and adjusting of panic and emergency power features.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Dimmers: Full-size units equal to 100 percent of amount installed for each size indicated, but no fewer than 20 units.
2. Fuses: Equal to 100 percent of amount installed for each size installed, but no fewer than three.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Damage from transient voltage surges.

2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Deep Roof Lighting.
2. Leviton Manufacturing Co., Inc.
3. Lithonia Lighting; Acuity Brands Lighting, Inc; Synergy Lighting Controls.
4. Lehigh.

2.2 GENERAL SYSTEM REQUIREMENTS

A. Compatibility:

1. Dimming control components shall be compatible with lighting fixtures, ballasts, and transformers.

B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.

1. Alternative Line-Voltage Surge Suppression: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" for Category A locations.

C. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

2.3 SYSTEM DESCRIPTION

A. Description: Microprocessor-based, solid-state controls consisting of control stations and a separately mounted dimmer cabinet.

1. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
2. System control shall include master station(s), wall stations, and dimmer panels.
3. Each zone shall be configurable to control the following light sources:

    a. Fluorescent lamps with electronic ballasts.
    b. Line-voltage incandescent lamps.
    c. Low-voltage incandescent lamps.
    d. Cold cathode lamps.
    e. Non-dimmed loads.
    f. LED lamps.

4. Control of each zone shall interface with controls for the following accessory functions:

    a. Curtains and drapes.
    b. Blackout curtains.
    c. Projector screens.
    d. Motorized partitions.
    e. Manually positioned partitions.

5. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.

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

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

2.4 CONTROL NETWORK

A. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.

B. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.

1. Control Voltage: 24- or 10-V dc.
2. Comply with ESTA E1.11/USITT DMX 512-A for data transmission.

2.5 MASTER-CONTROL STATIONS

A. Functions and Features:

1. Control adjustment of the lighting level for each scene of each zone, and adjustment of fade-time setting for each scene change from one preset scene to another. Controls shall use digital rocker switches with LCD graphic display of light level.
2. Master channel shall raise and lower lighting level of all zones.
3. Fade rate for each scene shall be adjustable from zero to 60 seconds.
4. Fade override control for each scene.
5. Recall each preset scene and allow adjustment of zone controls associated with that scene.
6. Lockout switch to prevent changes when set.
7. On and off scene controls for non-dim channel contactors.
8. Emergency-control push button to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
9. Master on and off switch; off position enables housekeeping controls.
10. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
11. Push buttons for accessory functions.
12. Enable and disable wall stations.
13. Communications link to other master stations.
14. Provide for connecting a portable computer to program the master station.
15. Rear-illuminate all scene-select buttons.
16. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.

B. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover.

2.6 PARTITIONED-SPACE MASTER-CONTROL STATION

A. Functions and Features:

1. Automatically combine and separate lighting and accessory function controls as spaces are configured with movable partitions; with controls for adjustment of the lighting level for each scene of each dimmer, and adjustment of fade-rate setting for each scene change from one preset scene to another.
2. Master controls shall accommodate partitioning the space into six adjacent rooms.
3. Manual controls to set up six scenes for each room. Include wall stations in each room to control scenes.
4. Master channel to raise and lower the lighting level of all zones.
5. Adjustable fade rate for each scene from zero to 60 seconds.

6. Fade override control for each scene.
7. On and off scene controls for non-dim channel contactors.
8. Emergency-control push button to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
9. Master on and off switch; off position enables housekeeping controls.
10. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
11. Push buttons for accessory functions.
12. Provide for connecting a portable computer to program the master station.
13. Rear-illuminate all scene-select buttons.
14. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.

B. Custom Graphics. Include a graphical display of room configurations and the names for each. Indicate the current spaces configuration with LCD graphic or LED-illuminated indicators, and show which wall stations are active. Inactive wall stations shall be automatically deactivated.

C. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover.

2.7 WALL STATIONS

A. Functions and Features:

1. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.
2. Controls to adjust the lighting level of each dimmer for each scene, and the fade time setting for each scene change from one preset scene to another.
3. Numbered push buttons to select scenes.
4. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting.
5. On switch turns all scenes of master station to full bright.
6. Push-button controls for accessory functions.

B. Mounting: Flush, wall box with manufacturer's standard faceplate.

C. Hand-Held Cordless Control: Scene-select and accessory function push buttons using infrared transmission.

2.8 DIMMER CABINETS

A. Factory wired, convection cooled without fans, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.

B. Ambient Conditions:

1. Temperature: 60 to 95 deg F.
2. Relative Humidity: 10 to 90 percent, noncondensing.
3. Filtered air supply.

C. Dimmer Cabinet Assembly: NRTL listed and labeled.

D. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.

1. Integrated Fault-Current Rating: 10,000-A RMS symmetrical.

E. Lighting Dimmers: Solid-state SCR dimmers.

1. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.
2. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IESNA's "IESNA Lighting Handbook."
3. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
4. Dimmed circuits shall be filtered to provide a minimum 350-mic.sec. current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load-current waveform.
5. Protect controls of each dimmer with a fuse and transient voltage surge suppression.

F. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.

G. Accessory function control modules shall be compatible with requirement of the accessory being controlled.

H. Digital Control Network:

1. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
2. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.

I. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.

1. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
2. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
3. Integrated Fault-Current Rating: Same value as listed for the panel.
4. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
5. Fabricate and test dimmer boards to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

2.9 PORTABLE COMPUTER

A. Description: As recommended by master-control-station manufacturer, to program master station and associated wall stations, and all interconnected master stations. Portable computer shall be laptop style with a battery runtime of at least two hours. Display shall be an 11-inch interactive-matrix LCD and shall have required hardware, firmware, and software to program specified control functions of master-control stations.

B. Software shall be configured and customized by master-station manufacturer.

2.10 MANUAL SWITCHES AND PLATES

A. Switches: Modular, momentary push-button, low-voltage type.

1. Color: White unless otherwise indicated; red when associated with emergency circuits.
2. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
3. Locator Light: Internal illumination.
4. Wall Plates: Comply with requirements in Section 262726 "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.11 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "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 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Unshielded, Twisted-Pair Data Cable: Category 5e. Comply with requirements in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method:

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271500 "Communications Horizontal Cabling."
3. Minimum conduit size shall be 1/2 inch.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

F. Install dimmer cabinets for each zone.

3.2 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identifying components and power and control wiring.

B. Label each dimmer module with a unique designation.

C. Label each scene control button with approved scene description.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

3. Emergency Power Transfer: Test listed functions.

D. Remove and replace malfunctioning dimming control components and retest as specified above.

E. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

F. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.4 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within five years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain central dimming controls. Laptop portable computer shall be used in training.

END OF SECTION 260933

SECTION 26 2200 - LOW-VOLTAGE TRANSFORMERS

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: dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, 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.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Acme Electric Corporation.
2. Challenger Electrical Equipment Corp.
3. Controlled Power Company.
4. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Products.
5. Federal Pacific Transformer Company.
6. General Electric Company.
7. Hammond Co.
8. Magnetek Power Electronics Group.
9. Micron Industries Corp.
10. Myers Power Products, Inc.
11. Siemens Energy & Automation, Inc.
12. Sola/Hevi-Duty.
13. Square D Co./Groupe Schneider NA; Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 49 gray.

F. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150-deg C rise above 40-deg C ambient temperature.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: Manufacturer's standard brackets.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 10 dBA.
2. 30 to 50 kVA: 15 dBA.
3. 51 to 150 kVA: 25 dBA.
4. 151 to 300 kVA: 30 dBA.
5. 301 to 500 kVA: 40 dBA.
6. 501 to 750 kVA: 50 dBA.
7. 751 to 1000 kVA: 50 dBA.
8. 1001 to 1500 kVA: 50 dBA.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. 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.

C. 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.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

SECTION 26 2413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

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. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.
7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For switchboards, overcurrent protective devices, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NECA 400.

1.9 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

C. Unusual Service Conditions: NEMA PB 2, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

2.2 SWITCHBOARDS

A. Subject to compliance with requirements, provide a comparable product 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. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.

2. Branch Devices: Panel mounted.
3. Section Alignment: Front aligned.

J. Front- and Rear-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Fixed and individually compartmented mounted.
3. Sections front and rear aligned.

K. Nominal System Voltage: 480Y/277 V.

L. Main-Bus Continuous: As shown on switchboard schedule.

M. Indoor Enclosures: Steel, NEMA 250, Type 1.

N. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

O. Barriers: Between adjacent switchboard sections.

P. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

Q. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in switchboard.

R. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

S. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable 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.

T. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

U. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

V. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

W. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

X. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

Y. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity,.
3. Copper feeder circuit-breaker line connections.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
6. 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.
7. Disconnect Links:
    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
8. 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.
9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

Z. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

AA. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

BB. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.3 SURGE PROTECTION DEVICES

A. Subject to compliance with requirements, provide a comparable product 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. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

1. SPDs with the following features and accessories:

a. Integral disconnect switch.
b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.
d. Form-C contacts rated at 2 A and 24-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
e. Surge counter.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

F. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Line to Line: 1000 V.

G. SCCR: Equal or exceed 100 kA.

H. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip for main circuit breaker disconnect and branch circuit breakers; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long and short time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.
4. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
5. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    h. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
    i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

a. Instantaneous trip.
b. Time adjustments for long- and short-time pickup.
c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 125-V dc.

9.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

D. Fuses are specified in Section 262813 "Fuses."

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.

f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Analog Meters:

1. Meters: 4-inch diameter or 6 inches square, flush or semiflush, with anti-parallax 250-degree scales and external zero adjustment.

D. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

E. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

F. Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

G. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

H. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.

5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording 15-minute integrated demand of totalized system.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Control Circuits: 24-V dc.

D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

F. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.8 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.

1. Nameplate: At least 0.032-inch- thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.

1. Nameplate: At least 0.0625-inch- thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

D. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

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

3.2 INSTALLATION

A. Install switchboards and accessories according to NECA 400.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

C. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

D. Support and secure conductors within the switchboard according to NFPA 70.

E. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

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

3.8 DEMONSTRATION

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

END OF SECTION 262413

SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. 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.

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

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Construction Manager's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    b. Outdoor Locations: NEMA 250, Type 3R.
    c. Kitchen or Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
    d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
    e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.

2. Height: 84 inches maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

    a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

b. Back Boxes: Galvanized steel.
c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Ten percent.

L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

A. Subject to compliance with requirements, provide a comparable product 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, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 24-V control circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Subject to compliance with requirements, provide a comparable product 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. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2. External Control-Power Source: 24-V control circuit.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 ELECTRONIC-GRADE PANELBOARDS

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

B. Subject to compliance with requirements, provide a comparable product 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.

C. Panelboards: NEMA PB 1; with factory-installed, integral SPD; labeled by an NRTL for compliance with UL 67 and UL 1449 after installing SPD.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

E. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

F. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

G. SPD.

1. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
2. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V.
    b. Line to Ground: 1200 V for 480Y/277 V.
    c. Neutral to Ground: 1200 V for 480Y/277 V.
    d. Line to Line: 2000 V for 480Y/277 V.

3. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.

d. Line to Line: 1200 V.

4. SCCR: Equal to the SCCR of the panelboard in which installed or exceed 100 kA.
5. Inominal Rating: 20 kA.

H. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
2. Copper equipment and isolated ground buses.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Subject to compliance with requirements, provide a comparable product 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. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Subfeed Circuit Breakers: Vertically mounted.
5. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Breaker handle indicates tripped status.

c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
g. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.

2.7 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.

K. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

L. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

M. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

N. Install filler plates in unused spaces.

O. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

P. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

Q. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.

2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

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

END OF SECTION 262416

SECTION 26 2726 - WIRING DEVICES

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. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Receptacles with integral surge-suppression units.
3. Isolated-ground receptacles.
4. Weather-resistant receptacles.
5. Snap switches and wall-box dimmers.
6. Communications outlets.
7. Floor service outlets, poke-through assemblies, and multi-outlet assemblies.

1.3 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.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Service/Power Poles: One for every 10, but no fewer than one.
2. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
3. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.
4. TVSS Receptacles: One for every 10 of each type installed, but no fewer than two of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

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

a. Cooper; 5351 (single), CR5362 (duplex).
b. Hubbell; HBL5351 (single), HBL5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

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

a. Cooper; VGF20.
b. Hubbell; GFR5352L.
c. Pass & Seymour; 2095.
d. Leviton; 7590.

C. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A:

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

a. Hubbell; GFTR20.
b. Pass & Seymour; 2095TR.

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Single Pole:

1) Cooper; AH1221.
2) Hubbell; HBL1221.
3) Leviton; 1221-2.
4) Pass & Seymour; CSB20AC1.

2. Two Pole:

1) Cooper; AH1222.
2) Hubbell; HBL1222.
3) Leviton; 1222-2.
4) Pass & Seymour: CSB20AC2.

3. Three Way:

1) Cooper; AH1223.
2) Hubbell; HBL1223.
3) Leviton; 1223-2.
4) Pass & Seymour; CSB20AC3.

4. Four Way:

1) Cooper; AH1224.
2) Hubbell; HBL1224.
3) Leviton; 1224-2.
4) Pass & Seymour; CSB20AC4.

C. Pilot-Light Switches, 20 A:

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

a. Cooper; AH1221PL for 120 and 277 V.
b. Hubbell; HBL1201PL for 120 and 277 V.
c. Leviton; 1221-LH1.
d. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277 V.

2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."

D. Key-Operated Switches, 120/277 V, 20 A:

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

    a. Cooper; AH1221L.
    b. Hubbell; HBL1221L.
    c. Leviton; 1221-2L.
    d. Pass & Seymour; PS20AC1-L.
2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.

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

    a. Cooper; 1995.
    b. Hubbell; HBL1557.
    c. Leviton; 1257.
    d. Pass & Seymour; 1251.

F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

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

    a. Cooper; 1995L.
    b. Hubbell; HBL1557L.
    c. Leviton; 1257L.
    d. Pass & Seymour; 1251L.

2.6 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

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

    a. Cooper; 6252.
    b. Hubbell; DR15.
    c. Leviton; 16252.
    d. Pass & Seymour; 26252.

B. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

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

a. Cooper; VGF20.
b. Hubbell; GF20LA.
c. Pass & Seymour; 2094.

C. Toggle Switches, Square Face, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.

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

a. Cooper; 7621 (single pole), 7623 (three way).
b. Hubbell; DS115 (single pole), DS315 (three way).
c. Leviton; 5621-2 (single pole), 5623-2 (three way).
d. Pass & Seymour; 2621 (single pole, 2623 (three way).

D. Lighted Toggle Switches, Square Face, 120 V, 20 A: Comply with NEMA WD 1 and UL 20.

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

a. Cooper; 7631 (single pole), 7633 (three way).
b. Hubbell; DS120IL (single pole), DS320 (three way).
c. Leviton; 5631-2 (single pole), 5633-2 (three way).
d. Pass & Seymour; 2625 (single pole), 2626 (three way).

2. Description: With neon-lighted handle, illuminated when switch is "off."

2.7 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.

C. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.8 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.9 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Four modular, keyed, color-coded, RJ-45 jacks for UTP cable complying with requirements in Section 271500 "Communications Horizontal Cabling."

2.10 POKE-THROUGH ASSEMBLIES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand.
3. Square D/Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold/Legrand.

B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks complying with requirements in Section 271500 "Communications Horizontal Cabling."
4. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables that comply with requirements in Section 271500 "Communications Horizontal Cabling."

2.11 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display 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 unacceptable.
   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.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. 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.

C. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz..

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 26 2813 - FUSES

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. Cartridge fuses rated 600 V ac and less for use in the following:

    a. Control circuits.
    b. Panelboards.
    c. Switchboards.
    d. Enclosed controllers.
    e. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting.
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class L, fast acting.
2. Feeders: Class L, fast acting.
3. Motor Branch Circuits: Class RK1, time delay.
4. Large Motor Branch (601-4000 A): Class L, time delay.
5. Power Electronics Circuits: Class J, high speed.
6. Other Branch Circuits: Class RK1, time delay.
7. Control Transformer Circuits: Class CC, time delay, control transformer duty.
8. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Construction Manager.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Molded-case circuit breakers (MCCBs).
3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

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

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1. 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.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

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

B. Source Limitations: Obtain enclosed circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

B. 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 Construction Manager no fewer than five 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 Construction Manager's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of 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

2.1 FUSIBLE SWITCHES

A. Subject to compliance with requirements, provide a comparable product 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. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate indicated fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

2.2 MOLDED-CASE CIRCUIT BREAKERS

A. Subject to compliance with requirements, provide a comparable product 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. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

D. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

E. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

F. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
9. Electrical Operator: Provide remote control for on, off, and reset operations.
10. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed 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.

3.2 INSTALLATION

A. Install individual wall-mounted circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

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

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION 262816

SECTION 26 2913 - ENCLOSED CONTROLLERS

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 the following enclosed controllers rated 600 V and less:

1. Reduced-voltage solid state.

B. Related Section:

1. Section 262923 "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.

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 reduced-voltage solid-state controllers.

1.8 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

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

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

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; connect factory-installed space heaters to temporary electrical service.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical systems without Construction Manager's written permission.
4. Comply with NFPA 70E.

1.12 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 REDUCED-VOLTAGE SOLID-STATE CONTROLLERS

A. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.

B. Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Subject to compliance with requirements, provide a comparable product by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.

e. Square D; a brand of Schneider Electric.

2. Configuration: Standard duty;.
3. Starting Mode: Current limit; field selectable.
4. Stopping Mode: Adjustable torque deceleration; field selectable.
5. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
6. Shorting and Input Isolation Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors.
7. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
8. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

9. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
10. SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with external feedback from the motor or driven equipment.
11. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:

    a. Adjusting motor full-load amperes, as a percentage of the controller's rating.
    b. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
    c. Adjusting linear acceleration and deceleration ramps, in seconds.
    d. Initial torque, as a percentage of the nominal motor torque.
    e. Adjusting torque limit, as a percentage of the nominal motor torque.
    f. Adjusting maximum start time, in seconds.
    g. Adjusting voltage boost, as a percentage of the nominal supply voltage.
    h. Selecting stopping mode, and adjusting parameters.
    i. Selecting motor thermal overload protection class between 5 and 30.
    j. Activating and de-activating protection modes.
    k. Selecting or activating communication modes.

12. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:

    a. Controller Condition: Ready, starting, running, stopping.
    b. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
    c. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

13. Controller Diagnostics and Protection:

    a. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
    b. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
    c. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.
    d. Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

14. Remote Output Features:

    a. All outputs prewired to terminal blocks.
    b. Form C status contacts that change state when controller is running.
    c. Form C alarm contacts that change state when a fault condition occurs.

C. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.
   1. Subject to compliance with requirements, provide a comparable product by one of the following:

      a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
      b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
      c. Rockwell Automation, Inc.; Allen-Bradley brand.
      d. Siemens Energy & Automation, Inc.
      e. Square D; a brand of Schneider Electric.

   2. Fusible Disconnecting Means:

      a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
      b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2.2 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.
   3. Kitchen or Wash-Down Areas: Type 4X, stainless steel.
   4. Other Wet or Damp Indoor Locations: Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

6. Hazardous Areas Indicated on Drawings: Type 7.

2.3 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, type.

a. Push Buttons: Recessed types; maintained as indicated.
b. Pilot Lights: LED types; colors as indicated; push to test.
c. Selector Switches: Rotary type.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable.
3. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

B. N.C. auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

E. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

F. Cover gaskets for Type 1 enclosures.

G. Terminals for connecting power factor correction capacitors to the line side of overload relays.

H. Spare control wiring terminal blocks, quantity as indicated; unwired.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

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

3.2 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch enclosed controller.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Install power factor correction capacitors. Connect to the line side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

I. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed controllers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

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 ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers at 80 percent.

E. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.

F. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers.

END OF SECTION 262913

SECTION 26 2923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

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 separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For each VFC, accessories, and components, from manufacturer.

1. Certificate of compliance.
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. Product Certificates: For each VFC from manufacturer.

E. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
e. 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.
f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Ten of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

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

1.9 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Cerus Industrial, Inc.
2. Danfoss Inc; Danfoss Drives Div.
3. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Business Unit.
4. Rockwell Automation, Inc; Allen-Bradley Brand.
5. Schneider Electric USA, Inc.
6. Siemens Energy & Automation, Inc.
7. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Constant torque and variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested 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.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 22 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 10 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
4. Under- and overvoltage trips.
5. Inverter overcurrent trips.
6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for

providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
7. Critical frequency rejection, with three selectable, adjustable deadbands.
8. Instantaneous line-to-line and line-to-ground overcurrent trips.
9. Loss-of-phase protection.
10. Reverse-phase protection.
11. Short-circuit protection.
12. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. 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.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. NC alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

    a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. 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.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 0- to 10-V dc.
b. A minimum of six multifunction programmable digital inputs.

2. Pneumatic Input Signal Interface: 3 to 15 psig.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

a. 0- to 10-V dc.
b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

4. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc), which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

5. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

F. 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: Two.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:

a. Monitoring: On-off status, all points as described on drawings.
b. Control: On-off operation, all points as described on drawings.

2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

B. Output Filtering: reactor.

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

D. EMI/RFI Filtering: surge protector.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
    a. CPT Spare Capacity: 100 VA.
6. Overload Relays: NEMA ICS 2.

a. Solid-State Overload Relays:

1) Switch or dial selectable for motor-running overload protection.
2) Sensors in each phase.
3) Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
5) Analog communication module.

b. NC isolated overload alarm contact.
c. External overload, reset push button.

2.7 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Lockable.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.
4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. NC bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with stainless-steel intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

G. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

H. Spare control-wiring terminal blocks; unwired.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install 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 Section 260529 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

G. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. VFCs will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 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 instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 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 8 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 Construction Manager before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

F. Set field-adjustable pressure switches.

3.8 PROTECTION

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

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 26 3213 - ENGINE GENERATORS

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 packaged engine-generator sets for emergency power supply with the following features:

1. [**Gas** engine.
2. Unit-mounted control and monitoring.
3. Performance requirements for sensitive loads.
4. Fuel system.
5. Outdoor enclosure.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. LP: Liquid petroleum.

C. EPS: Emergency power supply.

D. EPSS: Emergency power supply system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.

4. Include fuel consumption in **cubic feet per hour** at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95, 80, 70, and 50 deg F. Provide drawings showing requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to kw rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine-generator set and other components specified. Indicate access requirements affected by height.
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. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Certificates: For engine-generator set, 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: With engine and generator mounted on rails identify center of gravity and total weight, supplied enclosure, internal silencer, and each piece of equipment not integral to the engine-generator set, 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. Source quality-control reports, including, but not limited to the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
    b. Operating instructions laminated and mounted adjacent to generator location.
    c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Caterpillar; Engine Div.
2. Generac Power Systems, Inc.
3. Kohler Co.
4. Magnetek, Inc.
5. Onan/Cummins Power Generation; Industrial Business Group.
6. Spectrum Detroit Diesel.

B. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine-generator set housing, engine-generator set, batteries, battery racks, silencers, and sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.
3. Component Importance Factor: 1.5.

B. ASME Compliance: Comply with ASME B15.1.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements.

F. Noise Emission: 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.

G. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 40 deg C.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet.

H. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. EPSS Class: Engine-generator set shall be classified as a Class 2 in accordance with NFPA 110.

D. Induction Method: Turbocharged.

E. Governor: Adjustable isochronous, with speed sensing.

F. Emissions: Comply with EPA Tier 2 requirements.

G. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

H. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.

2. Output Connections: Three-phase, four wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

I. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When 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 hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

J. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

    a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When 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 hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

    a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 ENGINE

A. Fuel: **Natural gas**.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

F. 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: Adequate 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.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

G. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump. Comply with requirements in Section 232113 "Hydronic Piping" for coolant piping.

1. Configuration: Vertical air discharge.
2. Radiator Core Tubes: Aluminum.
3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
4. 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.
5. Fan: Driven by multiple belts from engine shaft.
6. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

H. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

I. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.

7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. 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 deg F to 140 deg F 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.

2.5 GASEOUS FUEL SYSTEM

A. Natural-Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping."

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:

1. **Natural-Gas**, Vapor-Withdrawal System:

    a. Carburetor.
    b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
    c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
    d. Fuel Filters: One for each fuel type.
    e. Manual Fuel Shutoff Valves: One for each fuel type.
    f. Flexible Fuel Connectors: Minimum one for each fuel connection.
    g. LP-gas flow adjusting valve.
    h. Fuel change gas pressure switch.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

C. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine-generator set battery.

F. Indicating Devices : As required by NFPA 110 for Level 1 system, including the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. EPS supplying load indicator.
5. Ammeter and voltmeter phase-selector switches.
6. DC voltmeter (alternator battery charging).
7. Engine-coolant temperature gage.
8. Engine lubricating-oil pressure gage.
9. Running-time meter.
10. Current and Potential Transformers: Instrument accuracy class.

G. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level 1 system, including the following:

1. Start-stop switch.
2. Overcrank shutdown device.
3. Overspeed shutdown device.
4. Coolant high-temperature shutdown device.
5. Coolant low-level shutdown device.
6. Low lube oil pressure shutdown device.
7. Air shutdown damper shutdown device when used.
8. Overcrank alarm.
9. Overspeed alarm.
10. Coolant high-temperature alarm.

11. Coolant low-temperature alarm.
12. Coolant low-level alarm.
13. Low lube oil pressure alarm.
14. Air shutdown damper alarm when used.
15. Lamp test.
16. Contacts for local and remote common alarm.
17. Coolant high-temperature prealarm.
18. Generator-voltage adjusting rheostat.

19. Run-Off-Auto switch.
20. Control switch not in automatic position alarm.
21. Low-starting air pressure alarm.
22. Low-starting hydraulic pressure alarm.
23. Low cranking voltage alarm.
24. Battery-charger malfunction alarm.
25. Battery low-voltage alarm.
26. Battery high-voltage alarm.
27. Generator overcurrent protective device not closed alarm.

H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

I. Connection to Datalink: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication. Provide connections for datalink transmission of indications to remote data terminals via Bacnet. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

J. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine-generator set battery.

K. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.

12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Lamp test.
16. Low cranking voltage alarm.
17. Generator overcurrent protective device not closed.

L. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

M. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. 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 disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs 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. Contacts shall be available for load shed functions.
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 disconnect device, 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.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other generator-set alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12 lead alternator.

E. Range: Provide extended range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 15 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 10 percent and stabilize at rated frequency within 2 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or pre-engineered galvanized-steel-clad, integral structural-steel-framed, erected on concrete foundation.

1. Structural Design and Anchorage: Comply with ASCE 7 for wind loads up to 100 mph.
2. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Hinged Doors: With padlocking provisions.
4. Space Heater: Thermostatically controlled and sized to prevent condensation.
5. Lighting: Provide weather resistant LED lighting with 50 footcandles average maintained.
6. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
7. Muffler Location: Within enclosure.

C. 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.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

D. Interior Lights with Switch: Factory-wired, vapor-proof fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.10 MOTORS

A. Description: NEMA MG 1, Design B, medium induction random-wound, squirrel cage motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. Motor Sizes: 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.

F. Temperature Rise: Match insulation rating.

G. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

I. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

2.11 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene separated by steel shims.
2. Shore "A" Scale Durometer Rating: 30.
3. Number of Layers: Four.
4. Minimum Deflection: 1 inch.

B. 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- 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.
6. Minimum Deflection: 1 inch.

C. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.12 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.13 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

3.2 PREPARATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager no fewer than five working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Install packaged engine-generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine-generator to allow service and maintenance.

C. Connect engine exhaust pipe to engine with flexible connector.

D. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90 degree bend in flexible conduit routed to the generator set from a stationary element.

G. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection

        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.

    b. Electrical and Mechanical Tests

        1) Perform insulation-resistance tests in accordance with IEEE 43.

            a) Machines larger than 200 horsepower. Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 horsepower or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Conduct performance test in accordance with NFPA 110.
        6) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. 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.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. 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.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet from edge of the generator enclosure, and compare measured levels with required values.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

M. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 24 months' full maintenance by skilled employees of 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.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213

SECTION 26 3600 - TRANSFER SWITCHES

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 transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Remote annunciator systems.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer and testing agency.

B. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems." 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."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "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.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches through one source from a 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. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Transfer Switches Using Molded-Case Switches or Circuit Breakers:
1. Subject to compliance with requirements, provide a product as described below.

a. Emerson; ASCO Power Technologies, LP.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.

3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

J. Battery Charger: For generator starting batteries.

1. Float type rated 10 A.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

K. 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.

L. 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 Section 260553 "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.

M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Testing Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during testing operation.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

I. Open Transition Transfer Switches: Include the following functions and characteristics:

1. Fully automatic break-before-make operation.
2. Inspection of the contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors.
3. Controlled by in-phase monitor and sensors confirming sources are present and acceptable.
    a. Initiation occurs without active control of generator.
    b. Controls ensure that open-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

J. In-Phase Monitor: 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.

K. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

L. Automatic Transfer-Switch Features:

1. Under-voltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.

2.4 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation panel and shall include the following:

1. 23” industrial touch panel monitor: Includes USB Ports, 2x Gigabit Ethernet Ports, 4GB of memory, Alarm speaker and Wall mount brackets.

2. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
3. Switch position.
4. Switch in test mode.
5. Check genset.
6. Genset supply load.
7. Genset running.
8. Not in auto.
9. High/low engine temperature.
10. Low oil pressure.
11. Low coolant level.
12. Low fuel level.
13. Emergency stop.
14. Overload.
15. Failure of communication link.
16. Messaging: Ability to message facility personnel is provided without the need of internet or e-mail server connections.
17. E-mail notification: Alarm e-mail notifications are distributed to pre-configured users at a configurable time delay.
18. Building management or other monitoring system interface: Annunciator panel must be capable of providing critical alarms and status to 3rd party monitoring system via Modbus/TCP.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

1. Visual indication of source acceptability, switch position, common alarm, time dely and Ethernet link activity.
2. Audible and visual alarm by severity level shall indicate communication error, ATS Lockt Out, Failure to Synchronize and Extended Parallel.
3. Communications: Two 10/100 Base-T (RJ-45) Ethernet Ports.
4. Ambient Operation Temperature: -4 to 158deg F (-20 to 70 deg C) @ 5-85% humidity.
5. Indicating Lights: Grouped for each transfer switch monitored.
6. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
7. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
8. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.5 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. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548.16 "Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Section 260529 "Hangers and Supports for Electrical Systems."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Section 260553 "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 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.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. 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.

4. 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. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
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.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

D. Testing Agency's Tests and Inspections:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. 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.

4. 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. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
g. 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.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

E. Coordinate tests with tests of generator and run them concurrently.

F. 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.

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

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 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 Section 017900 "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 26 4113 - LIGHTNING PROTECTION FOR STRUCTURES

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 lightning protection system for ordinary structures.

B. Section includes lightning protection system for the following:

1. Ordinary structures.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Master Label Certificate.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY or LPI Master Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. Subject to compliance with requirements, provide a comparable product by one of the following:

a. East Coast Lightning Equipment Inc.
b. ERICO International Corporation.
c. Harger.
d. Heary Bros. Lightning Protection Co. Inc.
e. Independent Protection Co.
f. Preferred Lightning Protection.
g. Robbins Lightning, Inc.
h. Thompson Lightning Protection, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

2.3 MATERIALS

A. Air Terminals:

1. Copper unless otherwise indicated.
2. 1/2-inch long.
3. Pointed tip.
4. Integral base support.

B. Air Terminal Bracing:

1. Copper.
2. 1/4-inch diameter rod.

C. Class 1 Main Conductors:

1. Stranded Copper: 57,400 circular mils in diameter.

D. Ground Loop Conductor: Stranded copper**.**

E. Ground Rods:

1. Material: Solid copper.
2. Diameter: 5/8 inch.
3. Rods shall be not less than 120 inches long.

F. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.

3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld.

C. 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.

3.3 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 would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 26 5119 - LED INTERIOR LIGHTING

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. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboards used for lighting control.
3. Section 260933 "Central Dimming Controls" or Section 260936.19 "Standalone Multipreset Modular Dimming Controls" for architectural dimming systems and for fluorescent dimming controls with dimming ballasts specified in interior lighting Sections.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For paints and coatings, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.2: For paints and coatings, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

E. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

F. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

G. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment and luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, 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.

D. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 20 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 10 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. Bulb shape complying with ANSI C79.1.

F. Lamp base complying with ANSI C81.61 or IEC 60061-1.

G. CRI of minimum 80. CCT of 3000 K.

H. Rated lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: Indicated on luminaire schedule.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

L. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear powder-coat finish.

2.3 CYLINDER

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. CREE Lighting
b. Gotham (Lithonia)

B. Minimum 1000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. With integral mounting provisions.

2.4 DOWNLIGHT

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

2.5 HIGHBAY, LINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

2.6 HIGHBAY, NONLINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

2.7 LINEAR INDUSTRIAL

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Housing and heat sink rated to the following:

1. Class 1, Division 2 Group(s) A and D.
2. NEMA 4X.
3. IP 54.
4. IP 66.
5. Marine and wet locations.
6. CSA C22.2 No 137.

2.8 LOWBAY

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

2.9 PARKING GARAGE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 2,000 lumens. Minimum allowable efficacy of 75 lumens per watt.

C. Low-profile housing and heat sink.

D. Fully gasketed and sealed. IP 65 rated.

E. Stainless-steel latches.

F. Integral pressure equalizer.

2.10 RECESSED LINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.11 SURFACE MOUNT, LINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.12 SURFACE MOUNT, NONLINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.13 SUSPENDED, LINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.14 SUSPENDED, NONLINEAR

A. Subject to compliance with requirements, provide a comparable product by one of the following:

a. H. E Williams
b. Lightolier
c. Hubbell

B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.15 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. prismatic glass
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear powder-coat finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.16 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.17 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with five 5/32-inch- diameter aircraft cable supports adjustable to.
2. Ceiling mount with four-point pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to.
3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.

4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 26 5619 - EXTERIOR LIGHTING

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. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multi-pole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboard-based lighting control.
3. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

    a. Manufacturer's Certified Data: Photometric data certified by manufacturer?s laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. LEED Submittals:

1. Product Data for Credit EA 5: For specified metering equipment.
2. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

D. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

E. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

F. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which equipment and luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, 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.

D. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Source quality-control reports.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.

2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 50of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

E. Mockups: For exterior luminaires, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including luminaire support components.
b. Faulty operation of luminaires and accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. CRI of minimum 80. CCT of 3000 K.

H. L70 lamp life of 35,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: Indicated on luminaire schedule.

L. In-line Fusing: On the primary for each luminaire.

M. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

N. Source Limitations: Obtain luminaires from single source from a single manufacturer.

O. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:

1. Subject to compliance with requirements, provide a comparable product by one of the following:
   a. H. E Williams
   b. Lightolier
   c. Hubbell
2. Luminaire Shape: Square.
3. Mounting: Pole with extruded-aluminum arm, 11 inchesin length.
4. Luminaire-Mounting Height: 24´ to 0˝.
5. Distribution: Type IV.
6. Diffusers and Globes: Prismatic glass.
7. Housings:

   a. Extruded-aluminum housing and heat sink.
   b. Clear powder-coat finish.

B. Bollard:

1. Subject to compliance with requirements, provide a comparable product by one of the following:
   a. H. E Williams
   b. Lightolier
   c. Hubbell
2. Shape: Round.
3. Height Above Finished Grade: 30 inches.
4. Overall Height: 36 inches.
5. Diameter: 6 inches.
6. Mounting: 3 point cast aluminum base.
7. Distribution: Type V.
8. Diffusers and Globes: Prismatic glass.

9. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. Clear powder-coat finish.

C. Perimeter:
1. Subject to compliance with requirements, provide a comparable product by one of the following:
    a. CREE Lighting
    b. Lightolier
    c. Hubbell
2. Shape: Square.
3. Dimensions: 12 inches.
4. Surface with grade.
5. Diffusers and Globes: Prismatic glass.
6. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. Clear powder-coat finish.

D. Canopy:

1. Subject to compliance with requirements, provide a comparable product by one of the following:
    a. CREE Lighting
    b. Lightolier
    c. Hubbell
2. Shape: Square.
3. Dimensions: 12 inches.
4. Diffusers and Globes: Prismatic glass.
5. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. Clear powder-coat finish.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage and coating.
c. CCT and CRI for all luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

    a. Color: Light bronze.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As selected from manufacturer's standard catalog of colors.
    b. Color: Match Architect's sample of manufacturer's standard color.
    c. Color: As selected by Architect from manufacturer's full range.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to a minimum 1/8 inch backing plate attached to wall structural members.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.

1. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by

troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.6 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

   a. IES LM-5.
   b. IES LM-50.
   c. IES LM-52.
   d. IES LM-64.
   e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.10 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding rods.
5. Grounding labeling.

1.3 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. EMT: Electrical metallic tubing.

C. TGB: Telecommunications grounding busbar.

D. TMGB: Telecommunications main grounding busbar.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:

1. Ground rods.
2. Ground and roof rings.
3. BCT, TMGB, TGBs, and routing of their bonding conductors.

B. Qualification Data: For Installer, installation supervisor, and field inspector.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Result of the ground-resistance test, measured at the point of BCT connection.
b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician, who shall be present at all times when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

A. Comply with J-STD-607-A.

2.2 CONDUCTORS

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

1. Harger Lightning and Grounding.
2. Panduit Corp.
3. Tyco Electronics Corp.

B. Comply with UL 486A-486B.

C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: No. 8 AWG.

D. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG 26 kcmils and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

E. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

B. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Chatsworth Products, Inc.
3. Harger Lightning and Grounding.
4. Panduit Corp.
5. Tyco Electronics Corp.

C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

D. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

E. Busbar Connectors: Cast silicon bronze, solderless compression or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.

F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Chatsworth Products, Inc.
2. Harger Lightning and Grounding.
3. Panduit Corp.

B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with J-STD-607-A.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a 4-inch
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inchesstainless-steel or copper-plated hardware for attachment to the rack.

2.5 GROUND RODS

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

1. Harger Lightning and Grounding.
2. Tyco Electronics Corp.

B. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet in diameter.

2.6 LABELING

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

1. Brother International Corporation.
2. HellermannTyton.
3. Panduit Corp.

B. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with J-STD-607-A.

3.3 APPLICATION

A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches

E. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch intervals.
4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.

    a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 4/0 AWG.

3.5 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.

B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.6 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of No. 4/0 AWG 168 kcmils unless otherwise indicated.

F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.

H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.

J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

K. Access Floors: Bond all metal parts of access floors to the TGB.

L. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.

1. Install the conductors in grid pattern on 4-foot centers, allowing bonding of one pedestal from each access floor tile.

2. Bond the TGB of the equipment room to the reference grid at two or more locations.
3. Bond all conduits and piping entering the equipment room to the TGB at the perimeter of the room.

M. Towers and Antennas:

1. Ground Ring: Buried at least 30 inches below grade and at least 24 inches from the base of the tower or mounting.
2. Bond each tower base and metallic frame of a dish to the ground ring, buried at least 18 inches below grade.
3. Bond the ground ring and antenna grounds to the equipment room TMGB or TGB, buried at least 30 inches below grade.
4. Bond metallic fences within 6 feet of towers and antennas to the ground ring, buried at least 18 inches below grade.
5. Special Requirements for Roof-Mounted Towers:

    a. Roof Ring: Meet requirements for the ground ring except the conductors shall comply with requirements in Section 264113 "Lightning Protection for Structures."
    b. Bond tower base footings steel, the TGB in the equipment room, and antenna support guys to the roof ring.
    c. Connect roof ring to the perimeter conductors of the lightning protection system.

6. Waveguides and Coaxial Cable:

    a. Bond cable shields at the point of entry into the building to the TGB and to the cable entrance plate, using No. 2 AWG bonding conductors.
    b. Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

3.7 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

B. Comply with IEEE C2 grounding requirements.

3.8 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.

1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

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 the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.

D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.

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

F. Prepare test and inspection reports.

END OF SECTION 000000

SECTION 27 0528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Optical-fiber-cable pathways and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface pathways.
5. Boxes, enclosures, and cabinets.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways and surface pathways and for each color and texture specified, 12 inches long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal 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 certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Alpha Wire Company.
4. Anamet Electrical, Inc.
5. Electri-Flex Company.
6. O-Z/Gedney.
7. Picoma Industries.

8. Republic Conduit.
9. Robroy Industries.
10. Southwire Company.
11. Thomas & Betts Corporation.
12. Western Tube and Conduit Corporation.
13. Wheatland Tube Company.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel or die cast.
b. Type: Setscrew or compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

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

1. Alpha Wire Company.
2. Arnco Corporation.
3. Endot Industries Inc.
4. IPEX.
5. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Mono-Systems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE PATHWAYS

A. General Requirements for Surface Pathways:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.

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

    a. Mono-Systems, Inc.
    b. Niedax-Kleinhuis USA, Inc.
    c. Panduit Corp.
    d. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. Hoffman.
6. Lamson & Sessions; Carlon Electrical Products.
7. Milbank Manufacturing Co.
8. Molex; Woodhead Brand.
9. Mono-Systems, Inc.
10. O-Z/Gedney.
11. Quazite:Hubbell Power Systems, Inc.
12. RACO; Hubbell.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-B.
2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.

3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

J. Gangable boxes are prohibited.

K. Hinged-Cover Enclosures: Comply with UL 50 and 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. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: IMC identified for such use.
3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:

a. Loading dock.

b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.
d. Gymnasiums

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: GRC.
6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway.
9. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface pathways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

C. Complete pathway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Pathways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
3. Arrange pathways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to GRC before rising above floor.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

P. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lbtensile strength. Leave at least 12 inchesof slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.

R. Surface Pathways:

1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
2. Install surface pathway with a minimum 2-inch radius control at bend points.
3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

T. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.

U. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center top bottom of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

CC. Set metal floor boxes level and flush with finished floor surface.

DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Unless otherwise indicated, support units on a level 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.

B. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

C. 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. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

D. Field cut openings for 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.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6 FIRESTOPPING

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

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 27 0544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

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. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

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

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

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

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

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized-steel sheet.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
1. Subject to compliance with requirements, provide a comparable product by one of the following:

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.
e. Proco Products, Inc.

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

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Subject to compliance with requirements, provide a comparable product by one of the following:

    a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

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

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

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

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

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."

b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 270544

SECTION 27 1100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

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. Telecommunications mounting elements.
2. Backboards.
3. Telecommunications equipment racks and cabinets.
4. Grounding.

B. Related Requirements:

1. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
2. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
3. Section 271500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.
4. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. LAN: Local area network.

C. RCDD: Registered Communications Distribution Designer.

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 equipment racks and cabinets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Certificates: For equipment frames 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. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment frames shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."

2.3 EQUIPMENT FRAMES

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. ADC.
2. Belden Inc.
3. Cooper B-Line.
4. Emerson Network Power Connectivity Solutions.
5. Hubbell Premise Wiring.
6. Leviton Commercial Networks Division.
7. Middle Atlantic Products, Inc.
8. Ortronics, Inc.
9. Panduit Corp.
10. Siemon Co. (The).
11. Tyco Electronics Corporation; AMP Products.

B. General Frame Requirements:

1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Module Dimension: Width compatible with EIA 310-D standard, 19-inch panel mounting.
3. Finish: Manufacturer's standard, baked-polyester powder coat.

C. Floor-Mounted Racks: Modular-type, steel or aluminum construction.

1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and dual power strip (one strip on each side of rack).
2. Baked-polyester powder coat finish.

D. Cable Management for Equipment Frames:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting.
3. twelve, 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
4. LED indicator lights for power and protection status.
5. LED indicator lights for reverse polarity and open outlet ground.
6. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
7. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
8. Cord connected with 15-foot line cord.
9. Rocker-type on-off switch, illuminated when in on position.
10. Peak Single-Impulse Surge Current Rating: 26 kA per phase.
11. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than 330 V.

2.5 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Telecommunications Main Bus Bar:

1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Comply with J-STD-607-A.

2.6 LABELING

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for materials and installation requirements for underground pathways.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.3 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration including optional identification requirements of this standard.

D. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

SECTION 27 1300 - COMMUNICATIONS BACKBONE CABLING

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. Pathways.
2. UTP cable.
3. 50/125-micrometer, optical fiber cabling.
4. Coaxial cable.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Cabling identification products.

B. Related Sections:

1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.4 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6 ACTION SUBMITTALS

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

1. For coaxial cable, include the following installation data for each type used:

    a. Nominal OD.
    b. Minimum bending radius.
    c. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
2. Cabling administration drawings and printouts.
3. Wiring diagrams to show typical wiring schematics including the following:

    a. Cross-connects.
    b. Patch panels.
    c. Patch cords.

4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
5. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

    a. Vertical and horizontal offsets and transitions.
    b. Clearances for access above and to side of cable trays.
    c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
    d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.8 CLOSEOUT SUBMITTALS

A. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Patch-Panel Units: three of each type.
2. Connecting Blocks: three of each type.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

F. Grounding: Comply with ANSI-J-STD-607-A.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.12 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.13 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.14 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for five years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within five years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

C. Cable Trays:

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

a. Cable Management Solutions, Inc.
b. Cablofil Inc.
c. Cooper B-Line, Inc.
d. Cope - Tyco/Allied Tube & Conduit.
e. GS Metals Corp.

2.

3. Cable Tray Material: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inches thick.

a. Basket Cable Trays: 12 inches wide and 2 inches deep. Wire mesh spacing shall not exceed 2 by 4 inches.
b. Trough Cable Trays: Nominally 12 inches wide.
c. Ladder Cable Trays: Nominally 18 inches wide, and a rung spacing of 12 inches.

D. Conduit and Boxes: Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated,3/4 by 48 by 96 inches. Comply with requirements in Section 061000 "Rough Carpentry" for plywood backing panels.

2.3 UTP CABLE

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

1. Belden CDT Inc.; Electronics Division.
2. Berk-Tek; a Nexans company.
3. CommScope, Inc.
4. Draka USA.
5. Genesis Cable Products; Honeywell International, Inc.
6. KRONE Incorporated.
7. Mohawk; a division of Belden CDT.
8. Nordex/CDT; a subsidiary of Cable Design Technologies.
9. Superior Essex Inc.
10. SYSTIMAX Solutions; a CommScope Inc. brand.
11. 3M.
12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, 100-pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

    a. Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG.
    b. Communications, Plenum Rated: Type CMP or MPP, complying with NFPA 262.
    c. Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, complying with UL 1666.
    d. Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG.
    e. Multipurpose: Type MP or MPG; or MPP or MPR.
    f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
    g. Multipurpose, Riser Rated: Type MPR or MPP, complying with UL 1666.

2.4 UTP CABLE HARDWARE

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

1. American Technology Systems Industries, Inc.
2. Dynacom Corporation.
3. Hubbell Premise Wiring.
4. KRONE Incorporated.
5. Leviton Voice & Data Division.
6. Molex Premise Networks; a division of Molex, Inc.

7. Nordex/CDT; a subsidiary of Cable Design Technologies.
8. Panduit Corp.
9. Siemon Co. (The).
10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

G. Patch Cords: Factory-made, 4-pair cables in 36-inchlengths; terminated with 8-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.5 OPTICAL FIBER CABLE

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

1. Berk-Tek; a Nexans company.
2. CommScope, Inc.
3. Corning Cable Systems.
4. General Cable Technologies Corporation.
5. Mohawk; a division of Belden CDT.
6. Nordex/CDT; a subsidiary of Cable Design Technologies.
7. Optical Connectivity Solutions Division; Emerson Network Power.
8. Superior Essex Inc.
9. SYSTIMAX Solutions; a CommScope Inc. brand.
10. 3M.
11. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: Multimode, 50/125-micrometer, 24-fiber, nonconductive, tight buffer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA/EIA-492AAAA-B for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

    a. General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP.
    b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    c. Riser Rated, Nonconductive: Type OFNR or OFNP, complying with UL 1666.
    d. General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP.
    e. Plenum Rated, Conductive: Type OFCP or OFNP, complying with NFPA 262.
    f. Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, complying with UL 1666.

5. Conductive cable shall be steel armored type.
6. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Orange for 62.5/125-micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.6 OPTICAL FIBER CABLE HARDWARE

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

1. ADC.
2. American Technology Systems Industries, Inc.
3. Berk-Tek; a Nexans company.
4. Corning Cable Systems.
5. Dynacom Corporation.
6. Hubbell Premise Wiring.
7. Molex Premise Networks; a division of Molex, Inc.
8. Nordex/CDT; a subsidiary of Cable Design Technologies.
9. Optical Connectivity Solutions Division; Emerson Network Power.
10. Siemon Co. (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: three for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.7 COAXIAL CABLE

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

1. Alpha Wire Company.
2. Belden CDT Inc.; Electronics Division.
3. Coleman Cable, Inc..
4. CommScope, Inc.
5. Draka USA.

B. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG59/U (Plenum Rated): NFPA 70, Type CMP.

1. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
2. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
3. Copolymer jacket.

D. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

1. CATV Cable: Type CATV, or CATVP or CATVR.
2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
3. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, complying with UL 1666.
4. CATV Limited Rating: Type CATVX.

2.8 COAXIAL CABLE HARDWARE

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

1. Aim Electronics; a brand of Emerson Electric Co.
2. Leviton Voice & Data Division.
3. Siemon Co. (The).

B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.9 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.10 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

G. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

H. Group connecting hardware for cables into separate logical fields.

I. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: 1.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration including optional identification requirements of this standard.

D. Comply with requirements in Section 271500 "Communications Horizontal Cabling" for cable and asset management software.

E. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

G. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical Fiber Cable Tests:

a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
b. Link End-to-End Attenuation Tests:

1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

F. End-to-end cabling will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 271300

SECTION 27 1500 - COMMUNICATIONS HORIZONTAL CABLING

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. UTP cabling.
2. 50/125-micrometer, optical fiber cabling.
3. Coaxial cable.
4. Cable connecting hardware, patch panels, and cross-connects.
5. Telecommunications outlet/connectors.
6. Cabling system identification products.
7. Cable management system.

B. Related Requirements:

1. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
2. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. LAN: Local area network.

G. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.

H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

I. RCDD: Registered Communications Distribution Designer.

J. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For coaxial cable, include the following installation data for each type used:

    a. Nominal OD.
    b. Minimum bending radius.
    c. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:

    a. Cross-connects.
    b. Patch panels.
    c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

C. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Patch-Panel Units: Three of each type.
2. Connecting Blocks: Three of each type.
3. Device Plates: Three of each type.
4. Multiuser Telecommunications Outlet Assemblies: Three of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight.
2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.

1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft., and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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. Grounding: Comply with J-STD-607-A.

2.3 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements in Section 061000 "Rough Carpentry" for plywood backing panels.

2.4 UTP CABLE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. ADC.
2. Belden Inc.
3. Berk-Tek; a Nexans company.
4. CommScope, Inc.
5. Draka Cableteq USA.
6. Genesis Cable Products; Honeywell International, Inc.
7. Mohawk; a division of Belden Networking, Inc.
8. Superior Essex Inc.
9. SYSTIMAX Solutions; a CommScope, Inc. brand.
10. 3M Communication Markets Division.
11. Tyco Electronics Corporation; AMP Products.

B.

C. Description: 100-ohm, four-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

    a. Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG.
    b. Communications, Plenum Rated: Type CMP or MPP, complying with NFPA 262.
    c. Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, complying with UL 1666.
    d. Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG.
    e. Multipurpose: Type MP or MPG; or MPP or MPR.
    f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
    g. Multipurpose, Riser Rated: Type MPR or MPP, complying with UL 1666.

2.5 UTP CABLE HARDWARE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Dynacom Inc.
5. Hubbell Premise Wiring.
6. Leviton Commercial Networks Division.
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Co. (The).
10. Tyco Electronics Corporation; AMP Products.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: Three for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: Three for each four-pair UTP cable indicated.

F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

G. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.6 OPTICAL FIBER CABLE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Belden Inc.
2. Berk-Tek; a Nexans company.
3. CommScope, Inc.
4. Corning Cable Systems.
5. CSI Technologies Inc.
6. General Cable Technologies Corporation.

7. Mohawk; a division of Belden Networking, Inc.
8. Superior Essex Inc.
9. SYSTIMAX Solutions; a CommScope, Inc. brand.
10. 3M Communication Markets Division.
11. Tyco Electronics Corporation; AMP Products.

B. Description: Multimode, 50/125-micrometer, 24-fiber, nonconductive, tight buffer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA-492AAAB for detailed specifications.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

    a. General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP.
    b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    c. Riser Rated, Nonconductive: Type OFNR or OFNP, complying with UL 1666.
    d. General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP.
    e. Plenum Rated, Conductive: Type OFCP or OFNP, complying with NFPA 262.
    f. Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, complying with UL 1666.

5. Conductive cable shall be steel armored type.
6. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
7. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Orange for 62.5/125-micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.7 OPTICAL FIBER CABLE HARDWARE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Berk-Tek; a Nexans company.
5. Corning Cable Systems.
6. CSI Technologies Inc.
7. Dynacom Inc.
8. Hubbell Premise Wiring.
9. Molex Premise Networks; a division of Molex, Inc.

10. Siemon Co. (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: Three for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths.

D. Cable Connecting Hardware:

1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.8 COAXIAL CABLE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Alpha Wire Company.
2. Belden Inc.
3. Coleman Cable, Inc.
4. CommScope, Inc.
5. Draka Cableteq USA.

B. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG59/U (Plenum Rated): NFPA 70, Type CMP.

1. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
2. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
3. Copolymer jacket.

D. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

1. CATV Cable: Type CATV, or CATVP or CATVR.
2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
3. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, complying with UL 1666.
4. CATV Limited Rating: Type CATVX.

2.9 COAXIAL CABLE HARDWARE

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. Emerson Network Power Connectivity Solutions.
2. Leviton Commercial Networks Division.
3. Siemon Co. (The).

B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.10 CONSOLIDATION POINTS

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. American Technology Systems Industries, Inc.
2. Belden Inc.
3. Chatsworth Products, Inc.
4. Dynacom Inc.
5. Hubbell Premise Wiring.
6. Molex Premise Networks; a division of Molex, Inc.
7. Ortronics, Inc.; a subsidiary of Legrand Group.
8. Panduit Corp.
9. Siemon Co. (The).

B. Description: Consolidation points shall comply with requirements for cable connecting hardware.

1. Number of Terminals per Field: Three for each conductor in assigned cables.
2. Number of Connectors per Field:

    a. Three for each four-pair UTP cable indicated.
    b. Three for each four-pair conductor group of indicated cables, plus 25 percent spare positions.

3. Mounting: Recessed in ceiling.
4. NRTL listed as complying with UL 50 and UL 1863.
5. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.11 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.

B. Workstation Outlets: Four-port-connector assemblies mounted in multigang faceplate.

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

4. Legend: Factory labeled by silk-screening or engraving for stainless steel brass faceplates.
5. Legend: Machine printed, in the field, using adhesive-tape label.
6. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.12 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with J-STD-607-A.

2.13 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.14 CABLE MANAGEMENT SYSTEM

A. Subject to compliance with requirements, provide a comparable product by one of the following:

1. iTRACS Corporation, Inc.
2. TelSoft Solutions.

B. Description: Computer-based cable management system, with integrated database and graphic capabilities.

C. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.

D. Information shall be presented in database view, schematic plans, or technical drawings.

1. AutoCAD drawing software shall be used as drawing and schematic plans software.

E. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

2.15 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.

E. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

F. Cable will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements in Section 270528 "Pathways for Communications Systems."
3. Comply with requirements in Section 270536 "Cable Trays for Communications Systems."

B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures:

1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
2. Install lacing bars and distribution spools.

3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. MUTOA shall not be used as a cross-connect point.
5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:

    a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
    b. Locate consolidation points for UTP at least 49 feet from communications equipment room.

6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.

2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

G. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

H. Group connecting hardware for cables into separate logical fields.

I. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: 1.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.

G. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

6. UTP Performance Tests:

    a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:

        1) Wire map.
        2) Length (physical vs. electrical, and length requirements).
        3) Insertion loss.
        4) Near-end crosstalk (NEXT) loss.
        5) Power sum near-end crosstalk (PSNEXT) loss.
        6) Equal-level far-end crosstalk (ELFEXT).

7) Power sum equal-level far-end crosstalk (PSELFEXT).
8) Return loss.
9) Propagation delay.
10) Delay skew.

7. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.3.
8. Coaxial Cable Tests: Conduct tests according to Section 274133 "Master Antenna Television System."
9. Final Verification Tests: Perform verification tests for UTP[**and optical fiber**] systems after the complete communications 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 digital subscription line telephone call.
    b. Data Tests: These tests assume the Information Technology Staff has a network installed and is 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.

D. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for five years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within five years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and

revisions when extending wiring to establish new workstation outlets. Include training in cabling administration software.

END OF SECTION 271500

SECTION 28 3111

DIGITAL, ADDRESSALBLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Fire-alarm control.
2. Digital Voice Commend Center/Unit.
3. System printer.
4. Manual fire-alarm boxes.
5. Smoke detectors.
6. Heat detectors.
7. Notification appliances.
8. Remote annunciators.
9. Addressable interface devices.
10. Digital alarm communicator transmitter.

B. Related Sections:
1. Division 1 in its entirety
2. Section 087100, “Door Hardware”
3. Section 211313, “Fire Suppression Sprinklers”
4. Division 23, Section for air handling systems.
5. Division 26, Sections for basic electrical requirements; conductors and cables; raceways and boxes; and wiring devices.
6. Section 281300, “Access Control System”

1.3 DEFINITIONS

A. AHJ: Authorities Having Jurisdiction.

B. Approved: Unless otherwise stated, materials, equipment or submittals approved by the Owner, Engineer, and AHJ.

C. CO: Contracting Officer.

D. FM: Factory Mutual.

E. Furnish: Supply materials.

F. Engineer: JVP Engineers, P.C.

G. FM Approved: Materials or equipment approved by Factory Mutual and included in the most recent edition of the FM Approval Guide.

H. Install: Install materials, mount and connect equipment or assemblies.

I. Provide: Furnish, install and connect.

J. LED: Light-emitting diode.

K. NICET: National Institute for Certification in Engineering Technologies.

L. UL: Underwriters Laboratories, Inc.

M. UL Listed: Materials or equipment listed by Underwriters Laboratories and included in the most recent edition of the UL Fire Protection Equipment Directory.

1.4 SYSTEM DESCRIPTION

A. Noncoded, UL-certified point-addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Provide labor, materials, and equipment for a complete and fully functional fire detection and emergency voice/alarm communication system as outlined in these specifications and shown on the drawings. The Contractor shall be responsible for compliance with the entire project specifications as well as the following guidelines.

B. The system shall be an active/interrogative type system where each addressable device is repetitively scanned, causing a signal to be transmitted to the main fire alarm control panel (FACP) indicating that the device and its associated circuit wiring is functional. Loss of this signal at the main FACP shall result in a trouble indication as specified hereinafter for the particular input.

C. The facility shall have an emergency voice alarm communication system. Digitally stored message sequences shall notify the building occupants that a fire or life safety condition has been reported. The fire alarm system shall also support emergency manual voice announcement capability, and shall include provisions for the system operator to override automatic messages.

D. The guidelines are not intended to be all-inclusive and do not limit or define the Contractor's Scope of Work. The work includes the following:
   1. Provide a fire alarm system design including drawings showing system coverage and other required elements for compliance with NFPA and all applicable codes.
   2. Provide design submissions to the Engineer and AHJ for review.
   3. Provide smoke detectors above all fire alarm panels (including remote power supplies), in elevator machine rooms, elevator lobbies, electrical/telecom rooms, and as otherwise indicated on the drawings.
   4. Provide audible (digital voice) notification coverage throughout the building. Install additional audible notification appliances as required by the AHJ.
   5. Provide visual notification coverage in areas indicated on the drawings and all other public and/or common areas as required by the AHJ.
   6. Provide remote annunciator panels as indicated on the drawings.
   7. Provide remote power supplies and amplifiers as necessary to serve all devices shown on the drawings.
   8. Provide conduit, wiring and system installation.
   9. Coordinate core drilling and firestopping locations with the general contractor.
   10. Paint all exposed conduits and back boxes installed in common/public areas. Conduits and junction boxes shall be painted to match the adjacent finish.

11. Provide dedicated 120V power emergency circuit(s) for fire alarm system panels.
12. Provide coordination of the work with other trades.
13. Provide on-site project supervision.
14. Provide the services of a factory-trained NICET Level III Certified Service Technician to coordinate and supervise the installation, adjustments and tests of this work, including connections and terminations within the FACP and programming the FACP.
15. Provide permits, fees, and other charges required for the work.
16. Prepare record documents, operating and maintenance instructions, and training of Owner's personnel.
17. Perform fire alarm system pre-testing prior to final system acceptance testing.
18. Perform final system acceptance testing, including megger tests, loop resistance tests, and functional pre-testing of all fire alarm system components.
19. Provide warranty of equipment and labor.

1.6 SEQUENCE OF OPERATION

A. See Fire Alarm Event Matrix on Drawings.

1.7 SUBMITTALS

A. General Submittal Requirements:
   1. Submittals shall be submitted and approved by the AHJ and Engineer.
   2. Refer to Division 1 for basic information relating to submittal requirements. Partial submittals will not be acceptable and will be returned without review. Before any work is commenced, the submittal must be approved by the Engineers and AHJ.
   3. Shop Drawings shall be prepared by persons with the following qualifications:
      a. Trained and certified by manufacturer in fire-alarm system design.
      b. Fire protection engineer registered in the State of Maryland or NICET-certified fire-alarm technician, Level III minimum.
      c. Licensed or certified by the AHJ.

B. Product Data: Provide product data for all materials to be utilized.

C. Fire Alarm Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Provide point-to-point wiring diagrams showing the points of connection and terminals used for all electrical field connections in the system, including all interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams shall show all connections from field devices to the FACP and remote fire alarm control units, initiating circuits, switches, relays, end of line resistors, shield termination and terminals. Typical wiring diagrams are not acceptable.
   2. Provide point-to-point wiring diagrams showing all internal panel wiring connections and jumper positions.
   3. Provide isometric drawing showing device locations, terminal cabinet locations, and all circuit layouts for all floors.
   4. System shall be design with 3-D modeling software consistent with the project requirements.
   5. Provide a complete description of the system operation, including a sequence of operations matrix.
   6. Provide a complete list of device addresses and corresponding messages.
   7. Include annotated catalog data showing manufacturer's name, model, voltage, and catalog numbers for all equipment and components.

8. Provide complete battery calculations showing total standby power and total alarm power required to meet the specified system performance. A complete list of current requirements during normal, supervisory, trouble, and alarm conditions for each system component shall be submitted with the calculations.
9. Provide complete voltage drop calculations to show that adequate voltage for proper operation is delivered to all visual signaling devices.
10. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Provide a color code schedule for the wiring.
11. Provide floor plans showing the location of all devices and equipment.
12. Provide data to indicate that each circuit is loaded to not more than 75-percent of maximum capacity.
13. Provide data on each circuit to indicate that there is at least 25-percent spare capacity for notification appliances and modules, 25-percent spare capacity for initiating devices and modules.

D. Field quality-control reports.

E. 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 1 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. Record copy of site-specific software.
4. 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.
5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

F. Software and Firmware Operational Documentation – For all software and firmware associated with the fire alarm system, provide the following:
1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.

1.8 OPERATION AND MAINTENANCE MANUALS

A. General: Provide operation and maintenance manuals not less than 30-days prior to the final acceptance testing of the entire system and after the preliminary testing has been completed. The manuals shall be used during the instruction period hereinafter specified. Provide six (6) bound copies of an Operation and Maintenance Manual. The manual shall include an index, copies of all approved shop drawings and submittal materials, and a complete parts list of all components. The manual shall also include, for each item, the manufacturer's name, the serial number of the part, an ordering number, if appropriate, and a physical and electrical description of the part. Following the acceptance test, drawings and submittal materials shall be updated as necessary to reflect as built conditions.

B. Record Drawing Software: Provide two (2) sets of compact discs containing CAD based drawings in DXF format of all as built drawings and schematics.

C. Fire Alarm Program: Maintain a disk copy of the fire alarm program in the fire alarm control panel for the duration of the acceptance test period.

1.9 AS BUILT DRAWINGS

A. General: Prepare and submit to the engineer six (6) sets of detailed "AsBuilt Drawings". The drawings shall be prepared on uniform sized sheets not less than 30-inches by 42-inches. These drawings shall be submitted within 2-weeks after the final acceptance test of the system. The drawings shall show the system as installed, including all deviations from both the project drawings and the approved shop drawings. The drawings shall include the following information:
   1. The exact locations and installation details of the installed equipment and address of each addressed device and zone.
   2. The address of each addressed device and zone.
   3. The installed wiring and color coding and wire tag notifications for the exact locations of all installed equipment.
   4. Locations of each End-of-Line Resistor, End-Of-Line Device and fault circuit isolator.
   5. Complete wiring diagrams showing connections between all devices and equipment, both factory and field wired. Include a riser diagram and drawings showing the asbuilt location of all devices and equipment. Specific point-to-point interconnections between all equipment and internal wiring of the equipment shall be shown. Typical point-to-point wiring diagrams are not acceptable.
   6. Layout of the remote annunciator panel and complete passive graphic floor plans.

B. Record Drawing Software: Provide two (2) CD containing AutoCAD Release 2007 based record drawings of all as built drawings and schematics. The Contractor shall show the equipment and addresses associated with each device or zone, as listed in Items 1through 6, above, on a separate layer of AutoCAD.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified for installation of all equipment required for this Project. Installation shall be accomplished by an electrical contractor with a minimum of 5-years of documented experience in installation of fire alarm systems. The Owner may reject any proposed installer who cannot show evidence of such qualifications.

B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system 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. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL or UL-listed alarm company.

1.11 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864 (9th edition) listing.

B. Technical Support: Beginning from date of final acceptance and approval, provide software support for two years.

C. Upgrade Service: Update software to latest version prior to final acceptance testing. Install and program software upgrades that become available within two years from date of final acceptance and approval. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.12 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. Smoke Detectors: Four (4) of each type installed.
   2. Heat Detectors: Two (2) of each type installed.
   3. Detector Bases: Four (4) of each type installed.
   4. Manual Pull Stations: Four (4) of each type installed.
   5. Interface Module: Four (4) of each type installed.
   6. Audible and Visual Notification Appliances: Four (4) of each type installed.
   7. Keys and Tools: Four (4) extra sets for access to locked and tamperproofed components.
   8. Fuses: Four (4) of each type installed.

B. Parts Guarantee: The Contactor shall agree to furnish replacement parts at the same price as parts furnished under this Contract for a period of 3 years after acceptance of the system, with a maximum inflation rate of 10 percent yearly not to exceed the parts normal retail price.

1.13 WARRANTY

A. The Contractor shall guarantee labor, materials and equipment provided under this contract against system defects for a period of two (2) years after the date of final acceptance of this work by the Owner.

B. Service shall be provided by the equipment supplier during the guarantee period seven (7) days a week including holidays and shall be responded to within four (4) hours after notification. All repairs shall be performed within twenty-four (24) hours after notification.

C. Should the Contractor fail to comply with the above requirements, the Owner will then have the option to make the necessary repairs and back charge the Contractor without any loss of warranty or guarantee as provided by the contract.

D. Any warranty which is in conflict with the above will not be acceptable.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a fire alarm system from the following manufacturers:

   1. Edwards: a UTC Building & Industrial Systems Company.
   2. Fire Control Instruments, Inc.; a Honeywell company.
   3. Fire Lite Alarms; a Honeywell company.
   4. Gamewell; a Honeywell company.

5. Notifier; a Honeywell company.
6. Siemens Building Technologies, Inc.; Fire Safety Division.
7. Silent Knight; a Honeywell company.
8. SimplexGrinnell LP; a Tyco International company.

2.2 EQUIPMENT AND MATERIAL, GENERAL:

A. All equipment and components shall be new, and compatible with the associated manufacturers listed in Section 2.1 above. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.

B. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc. before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.

C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. Fasteners and supports shall be adequate to support the required load.

D. Cabinet: Install control panel components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of all panels as well as all field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall say FACP and shall not be less than1-inch high. Provide prominent rigid plastic or metal identification plates for all lamps, circuits, meters, fuses and switches. The cabinet shall be provided in a sturdy steel housing, complete with backbox, hinged steel door with cylinder lock, display viewing windows, and surface mounting provisions. The enclosure shall be factory finished in baked enamel.

E. Silencing Switches: Provide an alarm silence switch at the FACP that will silence the audible notification appliances but not affect the visual notification appliance or FACP indicator. Provide trouble and supervisory silencing switch that will silence the audible trouble and supervisory signal, but not extinguish the visual indicator. This switch shall be overridden upon activation of a subsequent alarm

2.3 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by the following devices:
1. Manual pull stations.
2. Heat detectors.
3. Smoke detectors.
4. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:
1. Operate alarm notification appliances on the floor of alarm origin, floor above, and floor below.
2. Identify alarm at fire-alarm control panel and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Release fire and smoke doors normally held open.
5. Release normally secured doors for building egress.
6. Activate voice/alarm communication system.

7. Elevator smoke detectors shall recall elevators to primary or alternate recall floors and initiate illumination of the in-cab fireman's hat. Lobby smoke detectors shall cause the hat to become continuously illuminated. Elevator machine room and shaft smoke detectors shall cause the fireman's hat to intermittently flash.
8. Initiate elevator power shunt trip (elevator heat detector only).
9. Record events in the system memory.

C. Supervisory signal initiation shall be initiated by the following devices:
1. Valve supervisory switch.
2. High/low-air-pressure switch of dry pipe sprinkler systems.
3. Elevator power shunt-trip supervision.
4. Duct smoke detectors.
5. Generator run and fault conditions.

D. Supervisory signal shall initiate the following actions:
1. Identify supervisory signal at the fire alarm control panel and remote annunciators.
2. Transmit supervisory signal to the remote alarm receiving station.
3. Initiate shutdown of associated air handling unit and where indicated, close combination fire/smoke dampers (duct smoke detectors only).
4. Record events in system memory.

E. System trouble signal initiation shall be by the following devices and actions:
1. Open circuits, shorts, and grounds in fire alarm circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control panel.
4. Ground or a single break in fire-alarm control panel internal circuits.
5. Abnormal ac voltage at fire-alarm control panel.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.

F. Trouble signal shall initiate the following actions:
1. Identify trouble signal at the fire alarm control panel and remote annunciators.
2. Transmit trouble signal to the remote alarm receiving station.
3. Record events in system memory.

G. System Trouble and Supervisory Signal Actions: Initiate local notification appliance and annunciate at fire-alarm control panel and remote annunciators.

2.4 FIRE-ALARM CONTROL PANEL

A. General Requirements for Fire-Alarm Control Panel:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder.
2. Addressable initiation devices that communicate device identity and status.
   a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   1. Display: Liquid-crystal type, 4 lines of 40 characters, minimum.
   2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Elevator Recall/Shunt Trip:
   1. Smoke detectors at the following locations shall initiate automatic elevator recall and activate the in-cab flashing/continuously illuminated fireman's hat.
      a. Elevator lobby smoke detectors except the lobby detector on the designated floor.
      b. Smoke detector in elevator machine rooms and shafts.
   2. Elevator lobby detectors located on the designated recall floors shall initiate automatic recall and be programmed to move the cars to the alternate recall floor.
   3. Heat detectors located within the elevator machine rooms and freight elevator shafts shall initiate power shunt trip of associated elevators.

D. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in fire rated partitions/walls shall be connected to fire-alarm system.

E. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

F. Voice/Alarm Signaling Service:
   1. UL listed (864) audio paging/evacuation multiplex voice control system in accordance with referenced codes and standards. This system shall be manufactured by the same manufacturer as the main fire alarm system. The control system shall be modular in design, electrically supervised and mounted in the fire command center.
   2. The audio control panel shall include, but not be limited to, the following modules and functions:
      a. A paging microphone module. This shall include a panel mounted, coiled cord, hand held microphone with "push to talk" switch.
      b. A voice message module with manufacturer's standard voice message.
   3. System normal operating power shall be 120 volt AC supplied from the local emergency power panel. The system power supply shall be equipped with a battery charger that will maintain the entire voice system and amplifier system for 24 hours after the loss of normal operating power. The stand-by batteries shall be capable of operating the entire voice system for 30 minutes at the end of the 24-hour period.
   4. Audio power amplifiers shall be provided remotely where required. The power amplifiers shall be sized to provide for required speakers, plus 25 watts for future expansion. All amplifiers shall be electrically supervised and be UL listed for fire alarm signaling use.
   5. The amplifiers shall be listed to UL Standard 1711 and designed to normally operate from a 120 VAC emergency power circuit and 24 VDC provided by the voice control panel standby batteries.
   6. Provide digital voice message read-only memory voice message units to provide the automatic voice messages required.

G. System Bypass Switches/Buttons:
   1. A dedicated switch/button shall be provided for each of the desired functions:

a. Disabling the audio notification devices.
b. Disabling the visual notification devices.
c. Bypass HVAC shutdown.
d. Bypass elevator recall.
e. Bypassing security door (electric locks) unlocking.

2. Bypass switches/buttons shall be modular in design, electrically supervised and mounted in the FACP.
3. Activation of any bypass switches/buttons shall send a trouble signal to the FACP.
4. Resetting the FACP shall not change the state of these switches/buttons.
5. Bypass switches/button shall not require the use of a key or tool to operate.

H. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling line circuits, trouble signals, and supervisory signals shall be powered by 24-V dc source.

I. Secondary Power: 24-V dc supply system with sealed lead calcium batteries, automatic battery charger, and automatic transfer switch.

J. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 AUDIO AMPLIFIERS

A. The Audio Amplifiers will provide Audio Power for distribution to speaker circuits.

B. Multiple audio amplifiers may be mounted in a single enclosure.

C. The audio amplifier shall include an integral power supply.

D. Adjustment of the correct audio level for the amplifier shall not require any special tools or test equipment.

2.6 AUDIO MESSAGE GENERATOR (PRERECORDED VOICE)/SPEAKER CONTROL

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. Pre- and post-message tones shall be supported.

C. A built-in microphone shall be provided to allow paging through speaker circuits.

2.7 CIRCUITS

A. Fire alarm circuitry type shall be as follows:
1. Fire Alarm System Network Pathway: Class B.
2. Initiating Device Circuits: Class B.
3. Notification Appliance Circuits: Class B.
4. Audio Notification Speaker Circuits: Class B.
5. Signaling Line Circuits: Class B.

B. Fire alarm conductor size shall be as follows, unless otherwise specified by the manufacturer:
   1. Initiating Device Circuits: 18 AWG minimum.
   2. Notification Appliance Circuits: 14 AWG minimum.
   3. Audio Notification Speaker Circuits: 14 AWG minimum.
   4. Signaling Line Circuits: 18 AWG minimum.
   5. 120 VAC Power Circuits: 12 AWG minimum.

2.8 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be 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 (in matching color).
   1. 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 panel.
   2. Stations which require the replacement of any portion of the device after activation (e.g. glass rods) are not permitted.
   3. Station Reset: Key-operated switch.

2.9 SMOKE DETECTORS

A. General Requirements for Smoke Detectors:
   1. Comply with UL 268; operating at 24-V dc, nominal.
   2. Detectors shall be two-wire type.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
   7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control panel.
   8. Alarm Verification: System shall have alarm verification capability for smoke detectors.

B. Photoelectric Smoke Detectors:
   1. 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.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. 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.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.10 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
   1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.11 VISIBLE 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.
   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Visible Notification Appliances: Visual notification appliances shall consist of the following (no substitutions shall be permitted):
   1. Visual Only Device (Wall-Mount) – Cooper Wheelock Model RSS-24MCW-FW.
      a. Mounting: Wall mounted device. All devices in finished areas shall be flush-mounted. Where required to be surface-mounted, use manufacturer's surface-mount color-matched backbox.
      b. Flashing shall be in a temporal pattern, synchronized with other units within field of view.
      c. Strobe Leads: Factory connected to screw terminals.
      d. Mounting Faceplate: Factory finished, white with red **"FIRE"** lettering.
   2. Combination Audible/Visual Device (Wall-Mount) – Cooper Wheelock Model E70-24MCW-FW.

      a. Mounting: Wall mounted device. All devices in finished areas shall be flush-mounted. Where required to be surface-mounted, use manufacturer's surface-mount color-matched backbox.
      b. Flashing shall be in a temporal pattern, synchronized with other units within field of view.
      c. Strobe Leads: Factory connected to screw terminals.
      d. Mounting Faceplate: Factory finished, white with red **"FIRE"** lettering.

2.12 AUDIBLE NOTIFICATION APPLIANCES

A. Voice/Tone Notification Appliances shall consist of the following (no substitutions shall be permitted):
   1. Speakers

      a. Range: Rated 1/8 to 8 W.

      b. Mounting : Flush mounted with ceiling.

      c. Matching Transformers: Tap range matched to acoustical finished environment of speaker location.

      d. Factory finished white metal grille.

2.13 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
   1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.14 ADDRESSABLE INTERFACE DEVICE

A. Monitor Module: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
   1. Integral Relay: Where required, capable of providing a direct signal to initiate an auxiliary function.

B. Control Module: Microelectronic control module with relay, NRTL listed for use in performing an intended function for fire alarm systems and wired with normally closed contacts.

2.15 UNIVERSAL DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote monitoring station and shall comply with UL 632 and be listed and labeled by an NRTL. All fire alarm signals are transferred to the campus monitoring station via internet protocol (IP).

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically send and receive alarm, supervisory, and trouble signals to the campus Monitoring Station (Dispatcher). When contact is made with central station(s), signals shall be transmitted.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:
   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.

4. Manual test report function and manual transmission clear indication.
5. Communications failure with monitoring station.

D. Digital data transmission shall include, but not be limited to the following:
1. Address and description of the alarm-initiating device.
2. Address of supervisory-initiating device.
3. Address of trouble signal.
4. Loss of ac supply or power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger. Secondary power shall be capable of operating the system under quiescent load for 24 hours and then an additional alarm load of 30 minutes.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to monitoring station.

2.16 GRAPHIC ANNUNCIATOR PANEL

A. Graphic Annunciator Panel: Mounted in an aluminum frame with nonglare, minimum 3/16-inch-thick, clear acrylic cover over graphic representation of the facility. Graphic representation shall, at a minimum, include building footprint, stairs, elevators, and zone designations. Proposed layouts shall be approved by the Owner and Architect prior to fabrication.

1. Comply with UL 864.
2. Operating voltage shall be 24-V dc provided by a local 24-V power supply provided with the annunciator.
3. Include built-in voltage regulation, reverse polarity protection, RS 232/422 serial communications, and a lamp test switch.
4. Surface mounted in a NEMA 250, Type 1 cabinet, with key lock and no exposed screws or hinges.
5. Graphic representation of the facility shall be a CAD drawing at 1/8-inch per foot scale or larger.
6. Provide a red LED for each zone and alarm device type near the approximate location of the device on the graphic floor plan.
7. Provide an orange (amber) LED for each zone and supervisory device near the approximate location of the device on the graphic floor plan.
8. Provide a yellow LED for indication of trouble conditions.
9. Provide green LED’s for indication of power supervision.

Annunciator shall include all LED’s and control switches required by the authority having jurisdiction

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. The system shall be installed under the supervision of a qualified, trained, NICET (minimum Level III) Certified manufacturer's representative. The system shall be demonstrated to perform all of the functions as specified.

C. Equipment Mounting: Wall-mount all fire alarm control panels. Install fire-alarm control panels with tops of cabinets not more than 72 inches above the finished floor.

D. Electric Power: Provide primary power for the FACP from an emergency AC power circuit serving the building. Power shall be 120-volt AC service, transformed through a two-winding, isolation type transformer and rectified to low voltage DC for operation of all circuits and devices. Provide a separate NEMA 1 "General Purpose Enclosure" for the circuit breaker. The circuit breaker enclosure shall be painted red, marked "FACP", and provide with a lockable handle or cover.
   1. For all other fire alarm panels in the building, dedicated 120 VAC power (from an emergency circuit) shall be connected to each fire alarm control panel and power supply panel.
   2. No fire alarm system 120 VAC primary power circuit shall be loaded beyond 80% of the circuit's rated capacity.
   3. Design load connected to any power supply/standby battery shall not exceed 80% of its rated capacity.

E. Conductor Terminations: No specific color coding is required for any circuit; however, labeling of any circuit at terminal blocks in terminal cabinets, FACP, and remote fire alarm control units shall be provided at each conductor connection. Each conductor or cable shall have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FACP and remote fire alarm control unit shall contain a laminated drawing which indicates each conductor, its label, circuit and terminal. The laminated drawing shall be neat, using 12 point lettering minimum size, and mounted within each cabinet, panel or unit so that it does not interfere with the wiring or terminals.

F. All conductors shall be solid copper, unless the manufacturers installation instructions specifically require otherwise. Shielded wiring shall be utilized where recommended by the manufacturer. For shielded wiring, the shield shall be grounded at only one point, which shall be in or adjacent to the FACP

G. All system wire sizes shall be as determined suitable by the manufacturer and incompliance with the National Electric Code, but shall not be smaller than as specified herein.
   1. Wire size shall be sufficient to prevent voltage drop problems. Circuits operating at24-volts DC shall not operate at less than 21.6-volts. Circuits operating at any other voltage shall not have a voltage drop exceeding 10-percent of nominal voltage

H. All wiring shall be installed to National Electric Code and the State of Maryland Electrical Code standards.

I. Install all conductors in rigid metal conduit or electrical metallic tubing. The use of flexible conduit not exceeding 6-feet in length shall be permitted in initiating device circuits. Run conduit or tubing concealed unless specifically shown otherwise on the drawings. Conduit in mechanical, electrical, and telephone rooms that do not have a finished ceiling shall be run exposed. Conduit fill shall not exceed NEC limitations. Provide conduit marking tape at each conduit end and at 20-foot intervals in all accessible areas. Use (RWC) type tape (red and white checkered), only.

J. Smoke or Heat Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
3. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
4. HVAC: Locate detectors not closer than 3 feet from air-supply diffusers or return-air openings.
5. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

K. Duct Smoke Detectors:
1. Comply with NFPA 72 and IMC.
2. Install sampling tubes so they extend the full width of the duct.
3. Upon detection, duct detector shall shut down the associated air handling unit (through an interface module) and close associated damper through via relay modules, where applicable.

L. Heat Detectors in Elevator Machine Rooms: Coordinate temperature rating and location with sprinkler rating and location.

M. Exterior Audible Notification Appliance: Provide a weather-proof audible notification appliance at the exterior of the building. This exterior audible appliance shall sound upon sprinkler water flow.

N. Remote Alarm Indicators: Install near each smoke detector (including duct-type) and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

O. Notification Appliances: Install all fire alarm notification appliances as shown on the drawings. Wall-mounted strobes and combination speaker/strobes shall be installed with the bottom of the device at 80 inches above the finished floor.

P. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the controlled device or circuit. The following devices include, but are not limited to connections for:
1. Air handling unit shutdown.
2. Elevator recall and shunt trip.
3. Held-open or secured doors.

B. For fire-protection systems related to doors in fire-rated walls and partitions, comply with requirements of IBC and NFPA 72. Connect hardware and devices to fire-alarm system.
1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

3.3 FIRE ALARM CONTROL PANEL

A. Locate the FACP where indicated on the drawings. Surface mount the enclosure with the top of the cabinet 6-feet above the finished floor or center the cabinet at 5-1/2-feet,whichever is lower.

All conductor terminations shall be labeled and a drawing containing all conductors, their labels, their circuits and their interconnection shall be permanently mounted in the FACP.

3.4 REMOTE ANNUNCIATOR/LOCAL OPERATING CONSOLE (LOC)

A. Locate the annunciator at location shown on the drawings. Surface mount the panel, with the top of the panel 6-feet above the finished floor or center the panel at 5-1/2-feet,whichever is lower.

3.5 POWER SUPPLIES

A. Dedicated primary 120 VAC power (from an emergency circuit) shall be connected to each fire alarm control panel and power supply panel.

B. No fire alarm system 120 VAC primary power circuit shall be loaded beyond 80% of the circuit's rated capacity.

C. Design load connected to any power supply/standby battery shall not exceed 80% of its rated capacity.

D. Provide surge suppression in accordance with NFPA 70 and 72.

3.6 NAC PANELS

A. NAC panels where provided shall include:
1. A minimum of four (4) notification appliance circuits. The modules shall be designed to meet the required Style Y configurations.
2. A minimum of eight (8) amps total power output.
3. Built-in strobe synchronization.
4. Normal operating power for the NAC panel shall be 120 volt AC supplied from the nearest local power panel. All circuits shall be protected by circuit breakers of proper size.
5. Each NAC panel shall be provided with an emergency standby power system consisting of backup batteries. Batteries shall be sealed lead-acid or gel cell of sufficient capacity to provide the necessary standby and alarm operation as required by the AHJ. All calculations shall allow a minimum of 15% safety factor for battery degradation. Battery calculations shall be performed by utilizing the maximum prescribed (by manufacturer) loading of the fire alarm panel.
6. Each NAC panel shall accommodate all specified notification appliances. In addition, each notification appliance circuit shall allow a 20% expansion of connected devices.

3.7 CONDUIT

A. Install all wiring in rigid electrical metallic tubing (EMT) conduit.

B. Utilize ¾" minimum size EMT for all fire alarm cable installation. Steel set-screw fittings or compression fittings shall be used for all fire alarm conduits.

C. Metallic conduit shall be marked red every ten feet (via a band of 2-4" around the conduit), and all fire alarm junction boxes shall be painted red, except where required to match finishes as described in other parts of the construction documents.

3.8 JUNCTION BOXES

A. Sectional boxes shall not be used.

B. Each box shall be large enough to accommodate required splices and conduit in accordance with the NFPA 70.

C. All box covers shall be painted red.

D. UL listed terminal strips shall be provided for all wiring splices in junction boxes. The use of wire nuts to make wiring splices in strictly prohibited.

3.9 FIELD TERMINAL CABINETS (FTC)

A. FTC shall be UL listed for use in fire alarm wiring systems.

B. FTC minimum size shall be 12 inches by 12 inches by 4 inches with hinged lockable cover.

C. FTC shall be painted red with "Fire Alarm Equipment" label on the cover.

D. UL listed terminal strips shall be provided for all wiring splices in terminal boxes. All terminals shall be permanently labeled. The use of wire nuts to make wiring splices in the FTC is strictly prohibited.

3.10 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. All circuits within fire alarm panels, power supply, amplifiers, junction boxes and field terminals shall be proper identified with labels.

B. Install framed instructions in a location visible from fire-alarm control unit.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.
   1. Provide training to operating personnel in proper system operation and required user maintenance procedures.
   2. Provide two separate 4-hour training sessions for operating personnel. These sessions are to cover proper operating and response procedures. These instructions shall be sufficient to enable a previously untrained person to properly operate the system.

3.12 TESTS

A. Megger Tests: Prior to making any connections to panels or devices, all wiring shall be megger tested for insulation resistance, grounds, and/or shorts. Conductors with 300-voltrated insulation shall be tested at 250-volts DC, minimum. Conductors with 600-volt rated insulation shall be tested at 500-volts DC, minimum. Notify the Owner prior to conducting megger test to permit witnessing of the test. Test results shall be recorded for use at the final acceptance test.

B. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. Test results shall be recorded for use at the final acceptance test.

C. Preliminary Preliminary Testing: Conduct preliminary tests to ensure that all devices and circuits are functioning properly. Tests shall meet the requirements of Paragraph ~~3.9~~3.13 “Minimum System Tests” of this section. After preliminary testing is complete, provide a letter certifying that the installation is complete and fully operable. The letter shall state that each initiating and indicating device was tested in place and functioned properly. The letter shall also state that all panel functions were tested and operated properly. The letter shall include the names and titles of the witnesses to the preliminary tests. The Contractor and an authorized representative from each supplier of equipment shall be in attendance at the preliminary testing to make necessary adjustments. The construction manager must be present at the preliminary test. Smoke detector shall not be tested with magnetic device. Real smoke simulator shall be used to test smoke detector.

D. Final Testing:
1. Notify the Owner in writing when the system is ready for final acceptance testing. Submit request for test at least 15 calendar days prior to the test date.
2. Contractor shall perform and complete tests per this Paragraph and Paragraph “Minimum System Tests” in accordance with the methods in NFPA 72.
3. A final acceptance test will not be scheduled until the O&M Manuals are provided to the Owner and Engineer and the following are provided at the job site:
   a. Marked-up red line drawings of the system as actually installed.
   b. Megger test results.
   c. Loop resistance test results.
   d. Complete program printout including all input/output addresses.
4. Following acceptance of the system, as built drawings and Operation and Maintenance (O&M) Manuals shall be delivered to the Onwer for review and acceptance. Provide final test certificates as required by NFPA 72.

3.13 MINIMUM SYSTEM TESTS

A. General: Test the system in accordance with the procedures outlined in Chapter 10 of NFPA 72 and per Section 019113, “General Commissioning Requirements”. Additional required tests are as follows:
1. Verify the absence of unwanted voltages between circuit conductors and ground. The tests shall be accomplished at the preliminary test with results available at the final system test.
2. Verify that the control unit is in the normal condition as detailed in the manufacturer's operating and maintenance manual.
3. Test each initiating and indicating device and circuit for proper operation and response at the control unit.
4. Test the system for all specified functions in accordance with the Contract Drawings and specifications and the manufacturer's operating and maintenance manual.
5. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.
6. Determine that the system is operable under trouble conditions as specified.
7. Visually inspect all wiring.
8. Test the battery charger and batteries.
9. Verify that all software control and data files have been entered or programmed into the FACP. Hard copy records of the software shall be provided to the Owner.
10. Verify that red-line drawings are accurate.
11. Measure the current in circuits to assure there is the calculated spare capacity for the circuits.
12. Measure voltage readings for circuits to assure that voltage drop is not excessive.

13. Disconnect the verification feature for smoke detectors during tests to minimize the amount of smoke or test gas needed to activate the detector
14. Measure the voltage drop at the most remote appliance on each notification appliance circuit.
15. Provide sound pressure level testing to demonstrate minimum audible notification signaling is provided in all public spaces.

END OF SECTION

SECTION 311000 - 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. This Section includes the following:
   1. Protecting existing trees and shrubs to remain.
   2. Removing existing trees, shrubs, groundcovers, plants and grass.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Disconnecting, capping or sealing, and removing site utilities.
   7. Temporary erosion and sedimentation control measures.

B. Related Sections include the following:
   1. Division 01 Section "Temporary Facilities" for temporary utilities, temporary construction and support facilities, temporary security and protection facilities, and temporary erosion and sedimentation control procedures.
   2. Division 01 Section "Field Engineering" for verifying utility locations and for recording field measurements.
   3. Division 01 Section “Waste Management” for construction waste management and recycling requirements.
   4. Division 02 Section "Structure Demolition" for demolition of buildings, structures, and site improvements.
   5. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.

1.3 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; 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 more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Subcontractor's property and shall be removed from Project site.

1.5 SUBMITTALS

A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.
B. Record drawings, according to Division 01 Section "Project Record Documents," identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Meetings."

1.7 PROJECT 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.
   2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

C. Utility Locator Service: Subcontractor shall hire an independent utility locator service to verify all existing subsurface utility locations prior to the start of any demolition work.

D. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving."
   1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

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 requirements of authorities having jurisdiction and the approved sediment and erosion control drawings.

B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
   1. Do not store construction materials, debris, or excavated material within fenced area.
   2. Do not permit vehicles, equipment, or foot traffic within fenced area.

3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated.

C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
1. Cover exposed roots with burlap and water regularly.
2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
4. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status, as determined by Architect.

3.4 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
1. Arrange with utility companies to shut off indicated utilities. Cut and cap any remaining services not previously disconnected by others.

B. 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 seven (7) days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

C. Excavate for and remove underground utilities indicated to be removed.

D. Existing utilities may be abandoned in place if approved in writing by the Owner.

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, 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. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
4. Use only hand methods for grubbing within tree protection zone.
5. 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 whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
1. Do not stockpile topsoil within tree protection zones.
2. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, foundations, slabs, footings and aggregate base as indicated.
1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.8 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials that cannot be recycled or reused including trash and debris, and legally dispose of them off Owner's property.

1. 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.

END OF SECTION

SECTION 312319 - DEWATERING

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 construction dewatering.

B. Related Sections:
1. Division 01 Section "Contract Requirements" and "Photographic Documentation" for recording preexisting conditions and dewatering system progress.
2. Division 31 Section "Earth Moving" for excavating, backfilling, site grading, and for site utilities.
3. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
4. Division 33 Section "Subdrainage" for permanent foundation wall, underfloor, and footing drainage.

1.3 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain 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.
1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer registered in the District of Columbia, using performance requirements and design criteria indicated.
2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
3. Prevent surface water from entering excavations by grading, dikes, or other means.
4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
5. Remove dewatering system when no longer required for construction.

1.4 SUBMITTALS

A. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
   1. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
   2. Include a written plan for dewatering operations including control procedures to be adopted if dewatering problems arise.

B. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer registered in the District of Columbia responsible for their preparation.

C. Qualification Data: For qualified Installer, land surveyor and professional engineer.

D. Field quality-control reports.

E. Other Informational Submittals:
   1. Photographs or Videotape: Show existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by dewatering operations.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to dewatering including, but not limited to, the following:
      a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
      b. Geotechnical report.
      c. Proposed site clearing and excavations.
      d. Existing utilities and subsurface conditions.
      e. Coordination for interruption, shutoff, capping, and continuation of utility services.
      f. Construction schedule. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
      g. Testing and monitoring of dewatering system.
      h. Protection of WASA facilities.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
   1. Notify Owner no fewer than fourteen days in advance of proposed interruption of utility.
   2. Do not proceed with interruption of utility without Owner's written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.
   1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
   2. The geotechnical report is referenced elsewhere in the Project Manual.

C. Survey Work: Engage a qualified land surveyor registered in the District of Columbia to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
   1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS (Not Used)

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 dewatering operations.
   1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
   2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Monitor dewatering systems continuously.

E. Promptly repair damages to adjacent facilities caused by dewatering.

F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Division 01 Section "Temporary Facilities" during dewatering operations.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
   1. Space well points or wells at intervals required to provide sufficient dewatering.
   2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
   1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
   1. Maintain piezometric water level a minimum of 60 inches below surface of excavation.

E. 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. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

F. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
   1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

3.3 FIELD QUALITY CONTROL

A. Observation Wells: Provide, take measurements, and maintain at least the minimum number of observation wells or piezometers indicated; additional observation wells may be required by authorities having jurisdiction.
   1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
   2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
   3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

END OF SECTION

SECTION 31 50 00 - EXCAVATION SUPPORT AND PROTECTION

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 temporary excavation support and protection systems.

B. Related Sections:
   1. Division 01 Section "Contract Requirements" and "Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
   2. Division 01 Section "Temporary Facilities" for temporary utilities and support facilities.
   3. Division 31 Section "Dewatering" for dewatering system for excavations.

1.3 PERFORMANCE REQUIREMENTS

A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.
   1. Delegated Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer registered in the District of Columbia, using performance requirements and design criteria indicated.
   2. Prevent surface water from entering excavations by grading, dikes, or other means.
   3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation areas.
   4. Monitor vibrations, settlements, and movements.

1.4 SUBMITTALS

A. Shop Drawings: For excavation support and protection system.

B. Delegated-Design Submittal: For excavation support and protection system indicated to comply with performance requirements and design criteria, including analysis data

signed and sealed by the qualified professional engineer registered in the District of Columbia responsible for their preparation.

C. Coordinate first paragraph below with qualification requirements in Division 01 Section "Quality Control Program."
   1. "Qualification Data: For qualified land surveyor and professional engineer.

D. Other Informational Submittals:
   1. Photographs or Videotape: Show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by the absence of, the installation of, or the performance of excavation support and protection systems. Submit before Work begins.
   2. Record Drawings: Identifying and locating capped utilities and other subsurface structural, electrical, or mechanical conditions.
      a. Note locations and capping depth of wells and well points.

1.5 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at project site.
   1. Review methods and procedures related to excavation support and protection system including, but not limited to, the following:
      a. Geotechnical report.
      b. Existing utilities and subsurface conditions.
      c. Proposed excavations.
      d. Proposed equipment.
      e. Monitoring of excavation support and protection system.
      f. Working area location and stability.
      g. Coordination with waterproofing.
      h. Abandonment or removal of excavation support and protection system.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
   1. Notify Owner no fewer than fourteen days in advance of proposed interruption of utility.
   2. Do not proceed with interruption of utility without Owner's written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from the data.
   1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.

2. The geotechnical report is referenced elsewhere in the Project Manual.

C. Survey Work: Engage a qualified land surveyor registered in the District of Columbia to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
   1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.
   1. Corners: Roll-formed corner shape with continuous interlock.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of 3 inches or 4 inches.

E. Shotcrete: Comply with Division 03 Section "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.

F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

G. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

H. Tiebacks: Steel bars, ASTM A 722/A 722M.

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 that could develop during excavation support and protection system operations.
   1. Shore, support, and protect utilities encountered.
   2. Pre-auger holes for piles located adjacent to existing WASA facilities to remain.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.

D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Tiebacks: Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.
   1. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.
   2. Maintain tiebacks in place until permanent construction is able to withstand lateral soil and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
   1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
   2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
   3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.
   1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.
   2. Fill voids immediately with approved backfill compacted to density specified in Division 31 Section "Earth Moving."
   3. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION

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 SUBMITTALS

A. Product Data: For the following:
   1. Dielectric fittings.
   2. Identification devices.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1, "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.

1.6 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.

1.7 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 Division 03.

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 B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

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 D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

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.

C. AWWA Transition Couplings NPS 2 and Larger:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cascade Waterworks Mfg. Co.
   b. Dresser, Inc.; DMD Div.
   c. Ford Meter Box Company, Inc.; Pipe Products Div.
   d. JCM Industries.
   e. Smith-Blair, Inc.
   f. Viking Johnson.
3. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

D. Plastic-to-Metal Transition Fittings:

1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Spears Manufacturing Co.
3. Description: 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.

E. Plastic-to-Metal Transition Unions:
1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Colonial Engineering, Inc.
   b. NIBCO INC.
   c. Spears Manufacturing Co.
3. Description: MSS SP-107, PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

F. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:
1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Cascade Waterworks Mfg. Co.
b. Fernco, Inc.
c. Mission Rubber Company.
d. Plastic Oddities.

G. Description: ASTM C 1173 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. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Hart Industries, International, Inc.
e. Watts Water Technologies, Inc.
f. Zurn Plumbing Products Group; Wilkins Div.
3. Description: Factory fabricated, union, NPS 2 and smaller.
a. Pressure Rating: 150 psig minimum 250 psig at 180 deg F.
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:
1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Water Technologies, Inc.
3. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 and larger.
a. Pressure Rating: 150 psig minimum 175 psig minimum 300 psig.

b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
1. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

3. 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. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Calpico, Inc.
   b. Lochinvar Corporation.
3. 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. 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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Perfection Corporation.
   b. Precision Plumbing Products, Inc.
   c. Victaulic Company.

3. 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 Division 22 Section "Common Work Results for Plumbing."

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

C. Steel Pipe Sleeves: ASTM A 53/A 53M, 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 D 1785, 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 Division 33 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: Fiberboard.
   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: 0.032-inch- thick, polished brass or aluminum.
   2. Material: 0.0375-inch- thick stainless steel.
   3. Material: 3/32-inch- thick plastic laminate with 2 black surfaces and a white inner layer.
   4. Material: Valve manufacturer's standard solid plastic.
   5. Size: 1-1/2 inches in diameter, unless otherwise indicated.
   6. Shape: As indicated for each piping system.

L. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

M. Engraved Plastic-Laminate Signs: ASTM D 709, 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, unless otherwise indicated.
3. Thickness: 1/16 inch, for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
4. 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 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 C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
1. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.

3. Packaging: Premixed and factory packaged.

2.7 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix.
   1. Cement: ASTM C 150, Type I, portland.
   2. Density: 115- to 145-lb/cu. ft.
   3. Aggregates: ASTM C 33, natural sand, fine and crushed gravel or stone, coarse.
   4. Aggregates: ASTM C 33, natural sand, fine.
   5. Admixture: ASTM C 618, fly-ash mineral.
   6. Water: Comply with ASTM C 94/C 94M.
   7. Strength: 100 to 200 psig at 28 days.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure 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 (DN 50) 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 Division 33 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. Sleeves are not required for core-drilled holes.

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

K. 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.

L. Verify final equipment locations for roughing-in.

M. 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 Division 33 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 B 813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.

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 F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
   3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   5. PVC Nonpressure Piping: Join according to ASTM D 2855.
   6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   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 Division 09 painting Sections.

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 (610 mm), 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 (20.7-MPa) 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

B. 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

SECTION 334100 - 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.

1.2 SUMMARY

A. This Section includes gravity-flow, non-pressure storm drainage outside the building, with the following components:
   1. Special fittings for expansion and deflection.
   2. Cleanouts.
   3. Drains.
   4. Precast concrete and Cast-in-place concrete manholes, inlets and other structures.

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

B. RCP: Reinforced concrete pipe.

C. CI: Cast iron

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water. Pipe joints shall be at least silttight, unless otherwise indicated.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Special pipe fittings.
   2. Drains.

B. Shop Drawings: For the following:
   1. Manholes: Include plans, elevations, sections, details, and frames and covers. Include design calculations, and concrete design-mix report for cast-in-place manholes.

2. Catch Basins and Stormwater Inlets. Include plans, elevations, sections, details, and frames, covers, and grates.
3. Stormwater Detention Structures: Include plans, elevations, sections, details, frames and covers, design calculations, and concrete design-mix report.

C. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

D. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

E. Field quality-control test reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

D. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

1.7 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 fourteen days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy classes.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 PVC PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings, NPS 15 (DN 375) and Smaller: ASTM D 3034, SDR 35 with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

B. PVC Sewer Pipe and Fittings, NPS 18 (DN 450) and Larger: ASTM F 679, T-1 wall thickness, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.5 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, with bell-and-spigot ends and gasketed joints with ASTM C 443, rubber gaskets.
   1. Class IV, Wall A, B or C.
   2. Class V, Wall B or C.

2.6 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:
   1. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
   2. For Cast-Iron Soil Pipes: ASTM C 564, rubber.

3. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.7 CLEANOUTS

A. Gray-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

1. Available Manufacturers:
   a. Josam Company.
   b. MIFAB Manufacturing, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Wade Div.; Tyler Pipe.
   e. Watts Industries, Inc.
   f. Watts Industries, Inc.; Enpoco, Inc. Div.
   g. Zurn Industries, Inc.; Zurn Specification Drainage Operation.
2. Top-Loading Classification(s): Medium duty.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.
1. Available Manufacturers:
   a. Canplas Inc.
   b. IPS Corporation.
   c. NDS Inc.
   d. Plastic Oddities, Inc.
   e. Sioux Chief Manufacturing Company, Inc.
   f. Zurn Industries, Inc.; Zurn Light Commercial Specialty Plumbing Products.

2.8 DRAINS

A. Gray-Iron Area Drains: ASME A112.21.1M, round body with anchor flange and round secured grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.
1. Available Manufacturers:
   a. Josam Company.
   b. MIFAB Manufacturing, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Wade Div.; Tyler Pipe.
   e. Watts Industries, Inc.
   f. Watts Industries, Inc.; Enpoco, Inc. Div.

g. Zurn Industries, Inc.; Zurn Specification Drainage Operation.

2. Top-Loading Classification(s): Medium and heavy duty.

B. Gray-Iron Trench Drains: ASME A112.21.1M, 6-inch- (150-mm-) wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular secured grate. Include units of total length indicated and number of bottom outlets with inside calk or spigot connections, of sizes indicated.

1. Available Manufacturers:
   a. Josam Company.
   b. Smith, Jay R. Mfg. Co.
   c. Wade Div.; Tyler Pipe.
   d. Watts Industries, Inc.
   e. Watts Industries, Inc.; Enpoco, Inc. Div.
   f. Zurn Industries, Inc.; Zurn Specification Drainage Operation.
2. Top-Loading Classification(s): Medium and extra-heavy duty.

2.9 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Diameter: 48 inches (1200 mm) minimum, unless otherwise indicated.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
4. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
6. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
7. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
8. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
11. Protective Coating: Plant-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil (0.26-mm) minimum thickness applied to exterior surfaces.

12. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
    a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil (0.26-mm) minimum thickness applied to all surfaces, unless otherwise indicated.

B. Cast-in-Place Concrete Manholes: Construct of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.
1. Ballast: Increase thickness of concrete, as required to prevent flotation.
2. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
3. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
4. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
5. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
6. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
    a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil (0.26-mm) minimum thickness applied to all surfaces, unless otherwise indicated.

2.10 CONCRETE

A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water-cementitious materials ratio.
   1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
   2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.

C. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water-cementitious materials ratio.
   1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
   2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.

2.11 CATCH BASINS

A. Standard Precast Concrete Catch Basins: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
   1. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
   2. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1220-mm) diameter, and lengths to provide depth indicated.
   3. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
   4. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
   5. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
   6. Grade Rings: Include 2 or 3 reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
   7. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches.
   8. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. Cast-in-Place Concrete, Catch Basins: Construct of reinforced concrete; designed according to ASTM C 890 for structural loading; of depth, shape, dimensions, and appurtenances indicated.
   1. Bottom, Walls, and Top: Reinforced concrete.
   2. Channels and Benches: Concrete.
   3. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and

designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches.

C. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.
   1. Size: 24 by 24 inches (610 by 610 mm) minimum, unless otherwise indicated.
   2. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

D. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (178- to 229-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.
   1. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

2.12 STORMWATER INLETS

A. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to utility standards.

B. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.

C. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.

D. Frames and Grates: Heavy-duty frames and grates according to utility standards.

E. Curb Inlets: Vertical curb opening, of materials and dimensions indicated.

F. Gutter Inlets: Horizontal gutter opening, of materials and dimensions indicated. Include heavy-duty frames and grates.

G. Combination Inlets: Vertical curb and horizontal gutter openings, of materials and dimensions indicated. Include heavy-duty frames and grates.

H. Frames and Grates: Dimensions, opening pattern, free area, and other attributes indicated.

2.13 See Division 05 Section "Metal Gratings" for fabricated-steel grating.

2.14 STORMWATER DETENTION STRUCTURES

A. Cast-in-Place Concrete, Stormwater Detention Structures: Construct of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.
   1. Ballast: Increase thickness of concrete, as required to prevent flotation.
   2. Grade Rings: Include 2 or 3 reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and cover.
   3. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of structure to finished grade is less than 60 inches.

B. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, ductile-iron castings designed for heavy-duty service. Include 24-inch (610-mm) ID by 7- to 9-inch (178- to 229-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering "STORM SEWER" cast into cover.

2.15 MISCELLANEOUS MATERIALS

A. Paint: SSPC-Paint 16.

B. PE Sheeting: ASTM D 4397, with at least 8-mil (0.2-mm) thickness.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING APPLICATIONS

A. Pipe couplings and special pipe fittings 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, increaser/reducer-pattern, flexible or rigid couplings for pipes with different OD.

b. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

B. Special Pipe Fittings: Use for pipe expansion and deflection. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

C. Gravity-Flow, Nonpressure Sewer Piping: Use any of the following pipe materials for each size range:
1. NPS 6 to NPS 12 (DN 150 to DN 300): Hub-and-spigot, Extra-Heavy Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. NPS 6 to NPS 12 (DN 150 to DN 300): PVC sewer pipe and fittings,
3. NPS 15 (DN 375): Reinforced-concrete sewer pipe and fittings, gaskets, and gasketed joints.
4. NPS 18 to NPS 36 (DN 450 to DN 900): Reinforced-concrete sewer pipe and fittings, gaskets, and gasketed joints.
5. NPS 42 to NPS 60 (DN 1050 to DN 1500): Reinforced-concrete sewer pipe and fittings, gaskets, and gasketed joints.

3.3 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 design considerations into account. 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 manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. 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.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of [1] percent, unless otherwise indicated.
2. Install piping NPS 6 (DN 150) 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 piping with 48-inch minimum cover.
4. Install piping below frost line.
5. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
7. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Special pipe fittings.

3.4 PIPE JOINT CONSTRUCTION

A. Basic pipe joint construction is specified in Division 33 Section "Common Work Results for Utilities." Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. Join gravity-flow, nonpressure drainage piping according to the following:
1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
3. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
4. Join dissimilar pipe materials with nonpressure-type flexible or rigid couplings.

C. Join dissimilar pipe materials with pressure-type couplings.

3.5 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
1. Use light-duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.

2. Use medium-duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use extra-heavy-duty, top-loading classification cleanouts in roads areas.

B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep.

C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.6 DRAIN INSTALLATION

A. Install type of drains in locations indicated.
1. Use light-duty, top-loading classification drains in earth or unpaved foot-traffic areas.
2. Use medium-duty, top-loading classification drains in paved foot-traffic areas.
3. Use heavy-duty, top-loading classification drains in vehicle-traffic service areas.
4. Use extra-heavy-duty, top-loading classification drains in roads areas.

B. Embed drains in 4-inch (102-mm) minimum depth of concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

E. Assemble trench sections with flanged joints.

F. Embed trench sections in 4-inch minimum concrete around bottom and sides.

3.7 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections according to ASTM C 891.

C. Construct cast-in-place manholes as indicated.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.8 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.9 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318/318R.

3.10 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping."

3.11 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
   1. Close open ends of piping with at least 8-inch- thick, brick masonry bulkheads.
   2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
   1. Remove manhole or structure and close open ends of remaining piping.
   2. Remove top of manhole or structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Division 31 Section "Earth Moving."

3.12 PAINTING

A. Clean and prepare concrete manhole surfaces for field painting. Remove loose efflorescence, chalk, dust, grease, oils, and release agents. Roughen surface as required to remove glaze. Paint the following concrete surfaces as recommended by paint manufacturer:
   1. Cast-in-Place-Concrete Manholes: All exterior, except bottom.
   2. Precast Concrete Manholes: All exterior.

B. Prepare ferrous frame and cover surfaces according to SSPC-PA 1 and paint according to SSPC-PA 1 and SSPC-Paint 16. Do not paint surfaces with foundry-applied, corrosion-resistant coating.

3.13 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "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.

3.14 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) 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. 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 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. Option: Test concrete piping according to ASTM C 924 (ASTM C 924M).

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.

3.15 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION

SECTION 31 2000 - EARTH MOVING

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. Preparing subgrades for slabs-on-grade, walks and pavements.
2. Excavating and backfilling for buildings and structures.
3. Excavating and backfilling for utility trenches.
4. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.

B. Related Sections include the following:

1. Division 01 Section "Contract Requirements” and “Photographic Documentation" for recording pre-excavation and earthwork progress.
2. Division 01 Section "Temporary Facilities" for temporary controls, utilities, and support facilities.
3. Division 31 Section "Site Clearing" for temporary erosion and sedimentation control measures, site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
4. Division 31 Section "Dewatering" for lowering and disposing of ground water during construction.
5. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.

1.3 UNIT PRICES

A. Unit prices for earthwork are included in Division 01 Section "Unit Prices."

B. Quantity allowances for earthwork are included in Division 01 Section "Allowances."

1.4 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: Course placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Course 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: Course 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, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by an independent geotechnical testing agency, according to ASTM D 1586.

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

J. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

K. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

L. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Each type of plastic warning tape.
2. Geotextile.
3. Controlled low-strength material, including design mixture.

B. Samples: 12-by-12-inch Sample of separation geotextile.

C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 1557 for each on-site and borrow soil material proposed for fill and backfill.

D. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.

1.6 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Contractor shall employ independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

B. Preexcavation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.7 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Architect not less than fourteen days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

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: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, 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, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, 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 D 2940; 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 D 2940; 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 D 2940; 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 D 2940; 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 crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 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 D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

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: Class 2; AASHTO M 288.
2. Grab Tensile Strength: 157 lbf; ASTM D 4632.
3. Sewn Seam Strength: 142 lbf; ASTM D 4632.
4. Tear Strength: 56 lbf; ASTM D 4533.
5. Puncture Strength: 56 lbf; ASTM D 4833.
6. Apparent Opening Size: No. 40 sieve, maximum; ASTM D 4751.
7. Permittivity: [0.5] [0.2] [0.1] per second, minimum; ASTM D 4491.
8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

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: Class 2; AASHTO M 288.
2. Grab Tensile Strength: 247 lbf; ASTM D 4632.
3. Sewn Seam Strength: 222 lbf; ASTM D 4632.
4. Tear Strength: 90 lbf; ASTM D 4533.
5. Puncture Strength: 90 lbf; ASTM D 4833.
6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
7. Permittivity: 0.02 per second, minimum; ASTM D 4491.
8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 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:

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 earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 31 Section "Site Clearing."

C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing," during earthwork operations.

D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. 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.
2. Install a dewatering system, specified in Division 31 Section "Dewatering," to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.3 EXPLOSIVES

A. Explosives: 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.

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.
4. Pile in vicinity of WASA large diameter plans: Piles shall be pre-augered to below invert elevation of existing pipe before pile driving will be allowed.

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.

C. Trench Bottoms: 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.

1. For pipes and conduit less than 6 inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. 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 heavy pneumatic-tired equipment 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. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. 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 unit prices.

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 or utility pipe 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 and 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. 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.

D. Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 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.

E. Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the utility pipe or conduit.

G. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

H. Place and compact final backfill of satisfactory soil to final subgrade elevation.

I. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

J. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.13 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.

3.14 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 D 1557:

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 lawn 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.

3.15 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 Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 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.

3.16 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. 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.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, 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 1 test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than 3 tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet or less of wall length, but no fewer than 2 tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet or less of trench length, but no fewer than 2 tests.

E. 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 to depth required; recompact and retest until specified compaction is obtained.

3.17 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.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 2000

SECTION 32 1216 - ASPHALT PAVING

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. Cold milling of existing hot-mix asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt paving overlay.
5. Pavement-marking paint.

B. Related Sections:

1. Division 02 Section "Structure Demolition" for demolition, removal, and recycling of existing asphalt pavements, and for geotextiles that are not embedded within courses of asphalt paving.
2. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.
3. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants and fillers at paving terminations.

1.3 DEFINITION

A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
2. Job-Mix Designs: For each job mix proposed for the Work.

B. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

C. Samples: For each paving fabric, 12 by 12 inches minimum.

D. Samples for Verification: For the following products, in manufacturer's standard sizes unless otherwise indicated:

1. Each paving fabric, 12 by 12 inches minimum.
2. Each type and color of preformed traffic-calming device.
3. Each pattern and color of imprinted asphalt and precut marking material.

E. Qualification Data: For qualified manufacturer.

F. Material Certificates: For each paving material, from manufacturer.

G. Material Test Reports: For each paving material.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of District of Columbia Department of Public Works Stand Specifications for Highway Construction 1996 and revisions thereof, for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

D. Preinstallation Conference: Conduct conference at Project site, Per Division 1.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
b. Review condition of subgrade and preparatory work.
c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Prime Coat: Minimum surface temperature of 60 deg F.
2. Tack Coat: Minimum surface temperature of 60 deg F.
3. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.
4. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.6 deg C) at time of placement.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, 5 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. Fine Aggregate: ASTM D 1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: ASTM D 242 or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO MP 1a, PG 64-22, PG 58-28 and PG 70-22.

B. Asphalt Cement: ASTM D 3381 for viscosity-graded material and ASTM D 946 for penetration-graded material.

C. Prime Coat: Asphalt emulsion prime coat complying with requirements of District of Columbia Department of Public Works Stand Specifications for Highway Restoration 1996 and revisions thereof.

D. Tack Coat: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

E. Water: Potable.

F. Undersealing Asphalt: ASTM D 3141, pumping consistency.

2.3 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.

B. Sand: ASTM D 1073 or AASHTO M 29, Grade Nos. 2 or 3.

C. Joint Sealant: ASTM D 6690 or AASHTO M 324, Type I, Type II or III, Type IV, hot-applied, single-component, polymer-modified bituminous sealant.

D. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, Type N; colors complying with FS TT-P-1952.

1. Color: White and Yellow.

E. Pavement-Marking Paint: MPI #32 Alkyd Traffic Marking Paint.

1. Color: White and Yellow.

F. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than three (3) minutes.

1. Color: White and Yellow.

G. Pavement-Marking Paint: MPI #97 Latex Traffic Marking Paint.

1. Color: White and Yellow.

H. Glass Beads: AASHTO M 247, Type 1.

2.4 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course.
3. Surface Course.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment 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. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
3. 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.

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

D. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth of 1-1/2 inches.

2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Transport milled hot-mix asphalt to asphalt recycling facility.
7. Keep milled pavement surface free of loose material and dust.

3.3 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal. /sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

C. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

D. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.4 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch.

1. Clean cracks and joints in existing hot-mix asphalt pavement.
2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3.5 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.

C. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal. /sq. yd. Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure.

1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal. /sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.6 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at minimum temperature of 250 deg F.
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.7 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations." as shown on Drawings.
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.8 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to AASHTO T 245, but not less than 94 percent nor greater than 100 percent.
2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.9 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.10 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

1. Broadcast glass beads uniformly into wet pavement markings at a rate of 6 lb/gal.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Traffic-Calming Devices: Finished height of asphalt speed bumps above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.

    a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
    b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.12 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow milled materials to accumulate on-site.

END OF SECTION 32 1216

SECTION 32 1313 - CONCRETE PAVING

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 exterior cement concrete pavement for the following:

1. Driveways and roadways.
2. Parking lots.
3. Curbs and gutters.
4. Walkways.

B. Related Sections include the following:

1. Division 03 Section "Cast-in-Place Concrete Miscellaneous Cast-in-Place Concrete" for general building applications of concrete.
2. Division 31 Section "Earth Moving" for subgrade preparation, grading, and subbase course.
3. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants of joints in concrete pavement and at isolation joints of concrete pavement with adjacent construction.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Samples: 10-lb sample of exposed aggregate.

D. Qualification Data: For testing agency.

E. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

F. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:

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.

G. Field quality-control test reports.

H. Minutes of preinstallation conference.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.

C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.

D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

E. Mockups: Cast mockups of full-size sections of concrete pavement to demonstrate typical joints, surface finish, texture, color, and standard of workmanship.

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
2. Notify Architect seven days in advance of dates and times when mockups will be constructed.
3. Obtain Architect's approval of mockups before starting construction.
4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
5. Demolish and remove approved mockups from the site when directed by Architect.
6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

F. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete producer.
d. Concrete pavement subcontractor.

1.6 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

1. Use flexible or curved forms for curves with a radius 100 feet (30.5 m) or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

B. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

C. Epoxy-Coated Welded Wire Fabric: ASTM A 884, Class A, plain steel.

D. Reinforcing Bars: ASTM A 615, Grade 60; deformed.

E. Galvanized Reinforcing Bars: ASTM A 767, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615, Grade 60 deformed bars.

F. Epoxy-Coated Reinforcing Bars: ASTM A 775 or ASTM A 934; with ASTM A 615, Grade 60 deformed bars.

G. Steel Bar Mats: ASTM A 184; with ASTM A 615, Grade 60, deformed bars; assembled with clips.

H. Plain Steel Wire: ASTM A 82, as drawn.

I. Deformed-Steel Wire: ASTM A 496.

J. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, plain.

K. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars true to length with ends square and free of burrs.

L. Epoxy-Coated Joint Dowel Bars: ASTM A 775; with ASTM A 615, Grade 60, plain steel bars.

M. Tie Bars: ASTM A 615, Grade 60, deformed.

N. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

O. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

P. Epoxy Repair Coating: Liquid two-part epoxy repair coating, compatible with epoxy coating on reinforcement.

Q. Zinc Repair Material: ASTM A 780.

2.4 CONCRETE MATERIALS

A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, Type I or II:

   a. Fly Ash.
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

2. Blended Hydraulic Cement: ASTM C 595, Type IS, Portland blast-furnace slag; I (SM), slag-modified Portland cement.

B. Normal-Weight Aggregates: ASTM C 33, coarse aggregate, uniformly graded. Provide aggregates from a single source.

1. Maximum Coarse-Aggregate Size: 3/4 inch nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Exposed Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:

1. Aggregate Sizes: 1/2 to 3/4 inch nominal.

D. Water: ASTM C 94.

E. Air-Entraining Admixture: ASTM C 260.

F. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

1. Water-Reducing Admixture: ASTM C 494, Type A.
2. Retarding Admixture: ASTM C 494, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017, Type II.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz. /sq. yd. dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

1. Products:

a. Axim Concrete Technologies; Cimfilm.
b. Burke by Edeco; BurkeFilm.
c. ChemMasters; Spray-Film.
d. Conspec Marketing & Manufacturing Co., Inc.; Aquafilm.
e. Dayton Superior Corporation; Sure Film.
f. Euclid Chemical Company (The); Eucobar.
g. Kaufman Products, Inc.; Vapor Aid.
h. Lambert Corporation; Lambco Skin.
i. L&M Construction Chemicals, Inc.; E-Con.
j. MBT Protection and Repair, ChemRex Inc.; Confilm.
k. Meadows, W. R., Inc.; Sealtight Evapre.
l. Metalcrete Industries; Waterhold.
m. Nox-Crete Products Group, Kinsman Corporation; Monofilm.
n. Sika Corporation, Inc.; SikaFilm.
o. Symons Corporation; Finishing Aid.
p. Vexcon Chemicals, Inc.; Certi-Vex EnvioAssist.

E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

1. Products:

a. Anti-Hydro International, Inc.; AH Curing Compound #2 DR WB.
b. Burke by Edoko; Aqua Resin Cure.
c. ChemMasters; Safe-Cure Clear.
d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
e. Dayton Superior Corporation; Day Chem Rez Cure (J-11-W).
f. Euclid Chemical Company (The); Kurez DR VOX.
g. Kaufman Products, Inc.; Thinfilm 420.
h. Lambert Corporation; Aqua Kure-Clear.
i. L&M Construction Chemicals, Inc.; L&M Cure R.
j. Meadows, W. R., Inc.; 1100 Clear.
k. Nox-Crete Products Group, Kinsman Corporation; Resin Cure E.
l. Symons Corporation; Resi-Chem Clear.
m. Tamms Industries Inc.; Horncure WB 30.
n. Unitex; Hydro Cure 309.
o. Vexcon Chemicals, Inc.; Certi-Vex Enviocure 100.

F. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

1. Products:

a. Anti-Hydro International, Inc.; AH Curing Compound #2 WP WB.
b. Burke by Edoco; Resin Emulsion White.
c. ChemMasters; Safe-Cure 2000.
d. Conspec Marketing & Manufacturing Co., Inc.; W.B. Resin Cure.
e. Dayton Superior Corporation; Day-Chem White Pigmented Cure (J-10-W).
f. Euclid Chemical Company (The); Kurez VOX White Pigmented.
g. Kaufman Products, Inc.; Thinfilm 450.
h. Lambert Corporation; Aqua Kure-White.
i. L&M Construction Chemicals, Inc.; L&M Cure R-2.
j. Meadows, W. R., Inc.; 1200-White.
k. Symons Corporation; Resi-Chem White.
l. Tamms Industries, Inc.; Horncure 200-W.
m. Unitex; Hydro White.
n. Vexcon Chemicals, Inc.; Certi-Vex Enviocure White 100.

2.6 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber and ASTM D 1752, cork or self-expanding cork.

B. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

1. Manufacturers:

a. Bayer Corporation.
b. ChemMasters.
c. Conspec Marketing & Manufacturing Co., Inc.
d. Davis Colors.
e. Elementis Pigments, Inc.
f. Hoover Color Corporation.
g. Lambert Corporation.
h. Scofield, L. M.Company.
i. Solomon Colors.

2. Color: As selected by Architect from manufacturer's full range.

C. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery with 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.

D. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

E. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to requirements, and as follows:

1. Types I and II, non-load bearing and IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

F. 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.

1. Products:

a. Burke by Edeco; True Etch Surface Retarder.
b. ChemMasters; Exposee.
c. Conspec Marketing & Manufacturing Co., Inc.; Delay S.
d. Euclid Chemical Company (The); Surface Retarder S.
e. Kaufman Products, Inc.; Expose.
f. Metalcrete Industries; Surftard.
g. Nox-Crete Products Group, Kinsman Corporation; Crete-Nox TA.

h. Scofield, L. M. Company; Lithotex.
i. Sika Corporation, Inc.; Rugasol-S.
j. Vexcon Chemicals, Inc.; Certi-Vex Envioset.

G. Pigmented Mineral Dry-Shake Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

1. Products:

a. Conspec Marketing & Manufacturing Co., Inc.; Conshake 600 Colortone.
b. Dayton Superior Corporation; Quartz Tuff.
c. Euclid Chemical Company (The); Surflex.
d. Lambert Corporation; Colorhard.
e. L&M Construction Chemicals, Inc.; Quartz Plate FF.
f. MBT Protection and Repair, ChemRex Inc.; Mastercron.
g. Metalcrete Industries; Floor Quartz.
h. Scofield, L. M. Company; Lithochrome Color Hardener.
i. Symons Corporation; Hard Top.

2. Color: As selected by Architect from manufacturer's full range.

2.7 PAVEMENT MARKINGS

A. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with FS TT-P-115, Type [I] or AASHTO M 248, Type [N].

1. Color: As indicated.

B. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than three (3) minutes.

1. Color: As indicated.

C. Glass Beads: AASHTO M 247, Type 1.

2.8 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 4000 psi.
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
3. Slump Limit: 3 inches, plus or minus 1 inch (25 mm).

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 follows:

1. Air Content: 5-1/2 percent plus or minus 1.5 percent for 1-1/2-inch nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing admixture, high-range, water-reducing admixture, high-range, water-reducing and retarding admixture plasticizing and retarding admixture in concrete, as required, for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals, as follows:

1. Ground Granulated Blast-Furnace Slag: 25 percent.

G. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94 and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 deg F 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 C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For concrete mixes 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 mixes 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 pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
2. Proof-roll with a loaded 10-wheel tandem-axle dump truck weighing not less than 15 tons.
3. Subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch require correction according to requirements in Division 31 Section "Earth Moving."

C. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

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 for pavement 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 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. Zinc-Coated Reinforcement: Use galvanized steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

F. 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 D 3963.

G. 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 edgings 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 pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.

1. Continue steel reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
2. Provide tie bars at sides of pavement strips where indicated.
3. Butt Joints: Use epoxy bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. 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.
5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat 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, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 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. Protect top edge of joint filler during concrete placement 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, as follows to match jointing of existing adjacent concrete pavement:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch or 3/8-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
2. 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.
3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch or 3/8-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site.

F. Do not add water to fresh concrete after testing.

G. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

H. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.

1. Remove and replace concrete that has been placed for more than 15 minutes without being covered by top layer, or use bonding agent if approved by Architect.

J. Screed pavement surfaces with a straightedge and strike off.

K. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

L. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.

M. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.

N. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.

O. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

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 mix designs.

P. Hot-Weather 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 to 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.

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 bleed-water 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. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.8 SPECIAL FINISHES

A. Monolithic Exposed-Aggregate Finish: Expose coarse aggregate in pavement surfaces as follows:

1. Immediately after float finishing, spray-apply chemical surface retarder to pavement according to manufacturer's written instructions.
2. Cover pavement surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
3. Without dislodging aggregate, remove excess mortar by lightly brushing surface with a stiff, nylon-bristle broom.
4. Fine-spray surface with water and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.

B. Seeded Exposed-Aggregate Finish: Immediately after initial floating, spread a single layer of aggregate uniformly on pavement surface. Tamp aggregate into plastic concrete, and float finish to entirely embed aggregate with mortar cover of 1/16 inch.

1. Spray-apply chemical surface retarder to pavement according to manufacturer's written instructions.
2. Cover pavement surface with plastic sheeting, sealing laps with tape, and remove sheeting when ready to continue finishing operations.
3. Without dislodging aggregate, remove excess mortar by lightly brushing surface with a stiff, nylon-bristle broom.
4. Fine-spray surface with water and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on pavement surface according to manufacturer's written instructions and as follows:

1. Uniformly spread 25 lb/100 sq. ft. dampened slip-resistive aggregate over pavement surface in 2 applications. Tamp aggregate flush with surface using a steel trowel, but do not force below surface.
2. Uniformly distribute approximately two-thirds of slip-resistive aggregate over pavement surface with mechanical spreader, allow to absorb moisture, and embed by power floating. Follow power floating with a second slip-resistive aggregate application, uniformly distributing remainder of material at right angles to first application to ensure uniform coverage, and embed by power floating.
3. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
4. After curing, lightly work surface with a steel wire brush or abrasive stone and water to expose nonslip aggregate.

D. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to pavement surface according to manufacturer's written instructions and as follows:

1. Uniformly spread dry-shake hardener at a rate of 100 lb/100 sq. ft., unless greater amount is recommended by manufacturer to match pavement color required.
2. Uniformly distribute approximately two-thirds of dry-shake hardener over pavement surface with mechanical spreader, allow to absorb moisture, and embed by power floating. Follow power floating with a second dry-shake hardener application, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed by power floating.
3. After final floating, apply a hand-trowel finish followed by a broom finish to concrete.
4. Cure concrete with curing compound recommended by dry-shake hardener manufacturer. Apply curing compound immediately after final finishing.

3.9 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. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moist Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
3. 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.

3.10 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/4 inch.
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch (6 mm).
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches.
8. Joint Spacing: 3 inches.
9. Contraction Joint Depth: Plus 1/4 inch, no minus.
10. Joint Width: Plus 1/8 inch, no minus.

3.11 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow concrete pavement to cure for 28 days and be dry before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

1. Spread glass beads uniformly into wet pavement markings at a rate of 6 lb/gal.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 100 cu. yd. or 5000 sq. ft. or fraction thereof of each concrete mix placed each day.

    a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39; test 1 specimen at 7 days and 2 specimens at 28 days.

    a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mix will be satisfactory if average of any 3 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 shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall 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 shall 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. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.13 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 1313

SECTION 321400 - UNIT PAVING

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. Concrete pavers set in bituminous setting beds.
2. Detectable warning pavers in bituminous setting beds.
3. Asphalt-Block pavers set in bituminous setting beds.
4. Cast-in-place concrete edge restraints for permeable paving edging.

1.3 ACTION SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Product Data: For the following:

1. Pavers.
2. Bituminous setting materials.
3. Edge restraints.

C. LEED Submittals:

1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

D. Samples for Initial Selection: For the following:

1. Each type of unit paver indicated.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

E. Store asphalt cement and other bituminous materials in tightly closed containers.

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.

PART 2 - PRODUCTS

2.1 CONCRETE PAVERS

A. Regional Materials: Provide concrete pavers that have been manufactured within 500 miles (800 km) of Project site from aggregates[and cement] that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

B. Concrete Pavers:

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

a. Hanover Pavers

b. Colors:
1) Charcoal
2) Glacier White
3) Limestone Gray

c. Size: 4” x 24”x 3”

C. Detectable Warning Concrete Pavers:

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

a. Hanover Pavers

b. Detectable warning pavers

c. Color: Dark Grey

d. Size: 12” x 12”

2.2 ASPHALT-BLOCK PAVERS

A. Asphalt-Block Pavers: Solid units made from asphalt cement complying with ASTM D 312, Type III; inorganic stone dust or cement filler; and coarse aggregate, consisting of clean, hard, unweathered stone crushed into angular particles varying in size up to 3/8 inch (9.5 mm).

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

a. Hanover Architectural Products, Inc.

2. Thickness: 3 inches
3. Face Size: 4 by 6 inches
4. Dimensional Tolerances: Plus or minus 1/16 inch (1.6 mm).
5. Finish: Ground Finish.
6. Color: A80046

2.3 CURBS

A. Job-Built Concrete Edge Restraints – for permeable paving edging: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 3000 psi (20 MPa).

2.4 ACCESSORIES

A. Cork Joint Filler: Preformed strips complying with ASTM D 1752, Type II.

2.5 AGGREGATE SETTING-BED MATERIALS

A. Graded Aggregate for Curb Subbase: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 57.

2.6 BITUMINOUS SETTING-BED MATERIALS

A. Primer for Base: ASTM D 2028, cutback asphalt, grade as recommended by unit paver manufacturer.

B. Fine Aggregate for Setting Bed: ASTM D 1073, No. 2 or No. 3.

C. Asphalt Cement: ASTM D 3381, Viscosity Grade AC-10 or Grade AC-20.

D. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.

E. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.

2.7 BITUMINOUS SETTING-BED MIX

A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to 300 deg F (149 deg C).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

3.2 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Tolerances: Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.

C. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 079200 "Joint Sealants."

D. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.

3.3 BITUMINOUS SETTING-BED APPLICATIONS

A. Apply primer to concrete slab or binder course immediately before placing setting bed.

B. Place bituminous setting bed where indicated, in panels, by spreading bituminous material. Spread mix at a minimum temperature of 250 deg F (121 deg C).

C. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface.

D. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.

3.4 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.

END OF SECTION 321400

SECTION 321443 - POROUS UNIT PAVING

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 SCOPE OF WORK

A. Section Includes:

1. Concrete grid pavers with aggregate fill for vehicular and pedestrian use.
2. Aggregate setting bed for pavers.
3. Edge restraints.

1.3 ACTION SUBMITTALS

A. Product Data: For materials other than aggregates.

B. Product Data: For the following:

1. Pavers.

C. LEED Submittals:

1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

D. Sieve Analyses: For aggregate materials, according to ASTM C 136.

1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

PART 2 - PRODUCTS

2.1 CONCRETE UNIT PAVERS

A. Regional Materials: Pavers shall be manufactured within 500 miles (800 km) of Project site from aggregates[and cement] that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

B. Source Limitations: Obtain each type of paver from single source that has resources to provide materials and products of consistent quality in appearance and physical properties.

C. Concrete Grid Pavers: Grid paving units complying with ASTM C 1319, made from normal-weight aggregates.

1. Vehicular Permeable Pavers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following]:

a. Pavestone

b. Uni Eco Stone Pavers

c. Size: 9”x4.5”x3”

d. Color: grey

2. Pedestrian Permeable Pavers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following]:

a. Hanover Pavers

b. Permeable Pavers

c. Size: 12”x18”

d. Color: limestone grey

2.2 ACCESSORIES

A. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than [5000 psi and water absorption not more than 5 percent, in shapes and sizes indicated.

2.3 AGGREGATE SETTING-BED MATERIALS

A. Regional Materials: Aggregate and soil shall be extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

B. Graded Aggregate for Subbase: Sound crushed stone or gravel complying with [ASTM D 448 for Size No. 57

C. Graded Aggregate for Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8

D. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. [8] [9].

E. 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

F. 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

2.4 FILL MATERIALS

A. Graded Aggregate for Porous Paving Fill: Sound crushed stone or gravel complying with ASTM D 448 for Size No. [8] [9].

PART 3 - EXECUTION

3.1 PREPARATION

A. Proof-roll prepared subgrade according to requirements in Section 312000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with porous paver installation only after deficient subgrades have been corrected and are ready to receive [subbase and]base course for porous paving.

SECTION 323119.13 - DECORATIVE METAL SECURITY 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 SCOPE OF WORK

A. Section Includes:
   1. Swing gates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

C. Samples: For each fence material and for each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For gate operators to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 SWING GATES

A. Gate Configuration: Double leaf

B. Gate Frame Height: As indicated

C. Gate Opening Width: As indicated

D. Automated vehicular gates shall comply with ASTM F 2200

E. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes [1-1/2 by 1-1/2 inches (38 by 38 mm)] [1-3/4 by 1-3/4 inches (45 by 45 mm)] [2 by 2 inches (51 by 51 mm)] [2-1/2 by 2-1/2 inches (64 by 64 mm)] formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

F. Frame Corner Construction: Welded

G. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.

H. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.

2.3 GATE OPERATORS

A. Gate Operators:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:

   a. Commercial Swing Gate

   b. Long Fence – 301.350.2400 – Sean McFadden
   c. Color: Black
   d. Installation: concrete footers
   e. Lock: Button Key pad

B. Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.

2.4 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi (20 MPa), 3-inch (75-mm) slump, and 1-inch (25-mm) maximum aggregate size.

C. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M and specifically recommended by manufacturer for exterior applications.

2.5 GROUNDING MATERIALS

A. Grounding Connectors and Grounding Rods: Comply with UL 467.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.

3.2 PREPARATION

A. Stake locations of gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

1. Grounding-Resistance Tests:

3.5 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.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train. Owner's personnel to adjust, operate, and maintain gates.

END OF SECTION 323119.13

3.2 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be structurally unsound or visible in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment[or a block splitter] to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Provide curbs as indicated. Install curbs before placing unit pavers.

3.3 SETTING-BED INSTALLATION

A. Compact soil subgrade uniformly to at least [95] <Insert number> percent of [ASTM D 698] [ASTM D 1557] laboratory density.

B. Place [separation] [drainage] geotextile over prepared subgrade, overlapping ends and edges at least 12 inches (300 mm).

C. Place drainage geotextile over compacted subbase, overlapping ends and edges at least 12 inches (300 mm).

3.4 PAVER INSTALLATION

A. Set unit pavers on leveling course, being careful not to disturb leveling base.

B. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.

C. As work progresses, remove and replace pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

END OF SECTION 321443

SECTION 323223 - SEGMENTAL RETAINING WALLS

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 single depth segmental retaining walls with soil reinforcement.

1.3 PERFORMANCE REQUIREMENTS

A. Basis of Design: Design of segmental retaining walls is based on products indicated. If comparable products of other manufacturers are proposed, provide engineering design for proposed products, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.4 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing:

1.5 ACTION SUBMITTALS

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

B. Samples for Initial Selection: For concrete units.

1.6 INFORMATIONAL SUBMITTALS

A. Product Certificates: For segmental retaining wall units and soil reinforcement, from manufacturer.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for segmental retaining wall units and soil reinforcement.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects.

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.

PART 2 - PRODUCTS

2.1 SEGMENTAL RETAINING WALL UNITS

A. Concrete Vegetated Retaining Wall Units: ASTM C 1372, Normal Weight

1. Basis-of-Design Product: Subject to compliance with requirements, provide the following or approved equal:

a. Furbish- Vegetative Segmental Retaining Wall - Smart Slope.
1) Size: 15”x20”x10.5”
2) Reinforcement: polymeric straps
3) Brad Garner – 443.931.3067

B. Color: As selected by Architect from manufacturer's full range.

C. Shape and Texture: Provide units matching basic shape, dimensions, and face texture indicated by referencing manufacturer's pattern designation.

D. Planting Plan – see drawings.

2.2 INSTALLATION MATERIALS

A. Leveling Base: Comply with requirements in Section 312000 "Earth Moving" for base material, Section 334600 "Subdrainage" for drainage fill.

B. Drainage Fill: Comply with requirements in Section 334600 "Subdrainage."

C. Reinforced-Soil Fill: Comply with requirements in Section 312000 "Earth Moving" for satisfactory soils.

D. Subdrainage Pipe and Filter Fabric: Comply with requirements in Section 334600 "Subdrainage."

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 segmental retaining walls.

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

3.2 RETAINING WALL INSTALLATION

A. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.

B. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D 698.

C. 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.

D. 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.

E. Cap Units: Place cap units and secure with cap adhesive.

3.3 FILL PLACEMENT

A. Fill voids between and within units with specified planting soil mix, see planting soils spec section. Place fill as each course of units is laid.

B. Place, spread, and compact planting soil mix 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.

C. Place a layer of drainage fill at least 12 inches (300 mm) wide behind wall to within 12 inches (300 mm) of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.

D. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated[, sloped not less than 0.5 percent to drain].

E. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at base of wall away from wall. Provide uniform slopes that will prevent ponding.

F. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to manufacturer's written instructions. Embed reinforcement into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Comply with requirements in Section 312000 "Earth Moving" for field quality control.

3.5 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.

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 323223

SECTION 329100 - PLANTING SOILS

PART 1 - GENERAL

1.1 SUMMARY

A. The scope of work intended under this section includes furnishing all labor, materials, tools and equipment for soil blending, manufacturing and placement, or as may be reasonably inferred from, the drawings and as described in the Specifications. Such work shall include but is not limited to the following:

1. Furnish and install components that make up the Soil Mixes (Drainage Storage Gravel, Drainage Choker Gravel, Processed Sand, Organic Amendment, Compost, Inorganic Ammendments, and all pre-plant fertility amendments).
2. Furnish and install Soil Types that make up Soil Profiles.
    a. Ammended Site Soil
3. Furnish and install all fertility amendments.

1.2 SUBMITTALS

A. Testing During Construction: Contractor shall submit a one (1) gallon composite sample of each blended soil type representing every 150 cubic yards of specified material to a qualified testing agent.

1.3 QUALITY ASSURANCE

A. Furnish certificates of inspection of landscape materials to accompany shipments, as required by governmental authorities. Comply with applicable Federal, State, County, and local regulations governing landscape materials.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at the site.

1.5 SEQUENCING AND SCHEDULING

A. The Contractor is responsible for coordinating blending, shipping, delivery and installation of soils so that the following conditions are met:

PART 2 - PRODUCTS

2.1 AMMENDED SITE SOIL AND IMPORTED TOPSOIL

A. Recommendations for amendments are based on soil tests performed. Contractor shall perform their own soil tests for verification and submit results to landscape architect for final approval of soil amendment.

1. 60-65% sand and a maximum of 12% clay. There should be 5% organic content. Leafgro should be used to increase organic content if it is deficient.

B. Local Source(s) of Topsoil Material:

1. The topsoil shall be free from subsoil, clay lumps, stones, or similar objects larger than 3/8" in greatest diameter, brush, stumps, roots, objectionable weeds or litter, excess acid or alkali or any other material or substance which may be harmful to plant growth or a hindrance to subsequent smooth grading, planting and maintenance operations. Foreign material shall not exceed 2% by volume or weight. Texture to be defined by % sand, %clay, and % silt taken from sample material provided for texting. Topsoil shall also possess characteristics of representative productive soils in vicinity from which it is obtained, and be suitable for the germination of seeds and the support of vegetative growth. The topsoil shall be harvested at a single source from the O and or A horizons of the soil profile. Topsoil source location and extent of area suitable for harvest shall be approved by the Landscape architect.

2.2 BIORETENTION SOILS: (SEE CIVIL DWGS)

2.3 ORGANIC AMENDMENT

A. The following are some potential products that could be recommended as amendment. This is not an exhaustive list and other products may be recommended following testing.

B. LeafGro

1. Phone:(410)729-8636
Toll-Free:(888)A1-HUMUS
Fax:(410)729-8220
http://www.leafgro.com/

C. Black Castings™:

1. Worm castings produced without any waste products. Larva free Pure Black castings as provided by Vermitechnology Inc. Minimum organic matter content of 35% by weight as determined by loss on ignition (ASTM D 2974-87 Method D). Castings shall be free of sticks, stones and other debris and comply with the following:

Item	Criteria
Total Ash	70% or less
pH	5.0 to 7.5

% Moisture (wet wt. ba-	30% to 50%

2. Supplier or approved equal

   Circle Organics, LLC

   13000 South Tryon St. Suite F-192
   Charlotte NC 28278-7602
   877-ORG-FERT
   Email: sales@circleorganics.com

3. Application Rates per soil testing results and recommendations of landscape architect.

D. COMPOST

1. All compost will be decomposed and stable. All materials will be decomposed through aerobic processes. Material shall be free of debris and stones. Compost shall not be derived from more than 40% wood products.

2.4 ORGANIC SOIL AMENDMENTS

A. Following soil testing, amendments to be added per instruction of Landscape Architect. The following are some potential products that could be recommended as amendment. This is not an exhaustive list and other products may be recommended following testing.

B. VermaPlex™ Liquid Soil Amendment

1. Apply per soil tests and landscape architecture recommendations

2. Supplier or approved equal

   Circle Organics, LLC
   13000 South Tryon St. Suite F-192
   Charlotte NC 28278-7602
   877-ORG-FERT
   Email: sales@circleorganics.com

C. Pre-Plant Bio-Fertilizer – Trees and Shrubs

1. Apply per soil tests and landscape architecture recommendations

2. Supplier or approved equal

   Nutri-Cast™ (apply at label rates)
   Circle Organics, LLC
   13000 South Tryon St. Suite F-192
   Charlotte NC 28278-7602
   877-ORG-FERT
   Email: sales@circleorganics.com

D. Capsulated Gypsum Pellets

1. Apply per soil tests and landscape architecture recommendations

2. Supplier or approved equal

Kelly's Green Team
P.O. Box 725
Kirksville, MO 63501
(T) 660.627.5500
(F) 660.627.5504

E. Peat moss is not allowed for use as a soil amendment.

2.5 INORGANIC SOIL AMENDMENTS

A. Following soil testing, amendments to be added per instruction of Landscape Architect. The following are some potential products that could be recommended as amendment. This is not an exhaustive list and other products may be recommended following testing.

1. Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
2. Class: Class T, with a minimum 99 percent passing through No. 8 sieve and a minimum 75 percent passing through No. 60 sieve.
3. Class: Class O, with a minimum 95 percent passing through No. 8 sieve and a minimum 55 percent passing through No. 60 sieve.
4. Provide lime in form of dolomitic limestone.
5. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum 99 percent passing through No. 6 sieve and a maximum 10 percent passing through No. 40 sieve.
6. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
7. Aluminum Sulfate: Commercial grade, unadulterated.
8. Perlite: Horticultural perlite, soil amendment grade.
9. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate.
10. Sand: Clean, washed, natural or manufactured, free of toxic materials.
11. Diatomaceous Earth: Calcined, diatomaceous earth, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
12. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

2.6 TREE BEDDING PLANTER MULCH

A. Mulch: Hardwood Mulch

PART 3 EXECUTION

3.1 GENERAL

A. Obtain verification, in writing, that all of the planting areas receiving Soil Mixes have been prepared properly per drawings and specifications. Verify that subgrade and drainage components of the planters have been prepared, installed and approved per drawings, details and specifications prior to placement of Soil Mixes.

B. Verify that the surface moisture content is suitable for placement operations. Do not place or install any soil type during precipitation events, or when the subgrade is in a frozen condition.

C. In performing this work, Contractor shall avoid damage or displacement of other structures or materials such as walls, paving, drainage components, irrigation systems, filter fabric, or roofing membrane. The Contractor shall repair any such damage at his own expense.

D. Biological amendments should be added at time of planting.

3.2 Protection of Soil Mixes

A. Do not contaminate or compact during construction activities. Heavy construction equipment that could compact the soil should not be placed on the tree planting areas. Contractor shall ensure that this is done through the sequencing of construction, arranging staging areas, and providing protection of installed soil.

3.3 PLACEMENT OF PLANTING SOIL AT GRADE

A. Contractor shall verify that the soil has been installed in 4-6 inch lifts as per. This will insure that air pockets are removed from the soil.

B. Tree planting areas (at-grade):

1. Planting soil mix shall be installed next as an agronomic component, at a minimum depth of 36 inches .

C. Shrub and Groundcover planting areas (at-grade):

1. Planting Soil Mix shall be installed next as an agronomic component, at a minimum depth of 24 inches (24”).

3.4 FINAL REVIEW

B. Following all placement operations, the Landscape Architect must review and approve the installed soil profiles prior to any plant material and paving material placement.

C. Contractor must secure verification of compacted rates for all soil types within each soil profile that will support paving material.

D. Remove any material stockpiled on site, and clean all adjacent improvements per the requirements of Division 01.

END OF SECTION

SECTION 329200 - 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 SCOPE OF WORK

A. Section Includes:
   1. Sodding.
   2. Turf renovation.
   3. Erosion-control material(s).

1.3 ACTION SUBMITTALS

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

   1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

1.4 INFORMATIONAL SUBMITTALS

A. 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.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turfestablishment.

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" in TPI's "Guideline Specifications to Turfgrass Sodding."

1.6 PROJECT 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 [planting completion]

1. Spring Planting: Deciduous: February 1-May 1
2. Fall Planting: Deciduous: October 15-December 30.

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.

1.7 MAINTENANCE SERVICE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:

1. Sodded Turf: 30 days from date of planting completion and until sod is established.

PART 2 - PRODUCTS

2.1 TURFGRASS SOD

A. Turfgrass Sod: Certified, Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

2.2 INORGANIC SOIL AMENDMENTS (see planting soil specification)

2.3 ORGANIC SOIL AMENDMENTS (see planting soil specification)

2.4 FERTILIZERS (see planting soil specification)

2.5 PLANTING SOILS (see planting soil specification)

2.6 PESTICIDES (see planting soil specification)

2.7 EROSION-CONTROL MATERIALS

A. Erosion-Control Mats: Cellular, non-biodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface. Include manufacturer's recommended anchorage system for slope conditions.

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

a. Invisible Structures, Inc.; Slopetame 2.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.

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.

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. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches . Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

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 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.6 TURF RENOVATION

A. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.

3.7 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches (100 mm).

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height.

3.8 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with 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 Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with 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. 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.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION 329300 - 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 SCOPE OF WORK

A. Section Includes:

1. Plants.
2. Tree stabilization.
3. Landscape edgings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, including soils.

1. Plant List:
2. Plant Photographs: format of each required species and size of plant material

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified landscape Installer.

B. Product Certificates:

C. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

A. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

1.6 PROJECT CONDITIONS

A. 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: Evergreen: March 15-June 1, Deciduous: February 1-May 1

2. Fall Planting: Evergreen: September 15-December1, Deciduous: October 15-December 30.

1.7 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. Warranty Periods from Date of Planting Completion

a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.

1.8 MAINTENANCE SERVICE

A. Initial Maintenance Service for Trees and Shrubs:

1. Maintenance Period: 12 months from date of planting completion

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 Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1.

2.2 INORGANIC SOIL AMENDMENTS: See Soil Specification Section 329100

2.3 ORGANIC SOIL AMENDMENTS: See Soil Specification Section 329100

2.4 FERTILIZERS: See Soil Specification Section 329100

2.5 PLANTING SOILS: See Soil Specification Section 329100

2.6 MULCHES

A. Organic Mulch: (For more planting beds) Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Shredded hardwood

B. Mineral Mulch: (For bioretention planting areas) Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:

2.7 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.

2.8 PESTICIDES (SEE SOILS SPECIFICATION)

2.9 TREE STABILIZATION MATERIALS

A. Stakes and Guys:

1. Upright and Guy Stakes: Rough-sawn, sound, new [hardwood] [softwood with specified wood pressure-preservative treatment], free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
2. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.
3. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.

2.10 LANDSCAPE EDGINGS

A. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221 (ASTM B 221M), Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.

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

3.2 PLANTING AREA ESTABLISHMENT

A. Loosen subgrade of planting areas to a minimum depth of 8 inches for gournd cover, 24 inches for shrubs, 36 inches for trees] Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.3 EXCAVATION FOR TREES AND SHRUBS

A. Subsoil and topsoil removed from excavations may be used as planting soil.

B. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

C. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

3.4 TREE, SHRUB, AND VINE PLANTING

A. Before 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.

3.5 TREE STABILIZATION

A. Install trunk stabilization as follows unless otherwise indicated:
   1. Use two stakes for trees up to 12 feet (3.6 m) high and 2-1/2 inches (63 mm) or less in caliper; three stakes for trees less than 14 feet (4.2 m) high and up to 4 inches (100 mm) in caliper. Space stakes equally around trees.

3.6 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines in even rows with triangular spacing.

B. Dig holes large enough to allow spreading of roots.

C. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

D. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.7 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.

3.8 EDGING INSTALLATION

A. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately 36 inches apart, driven below top elevation of edging.

3.9 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. Spray or treat as required to keep trees and shrubs free of insects and disease.

3.10 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with 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 Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.11 DISPOSAL

A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 329300