GGLO

ARCHITECTURE
INTERIORS
LANDSCAPE
URBAN DESIGN

SPECIFICATIONS FOR:

BAKER HEIGHTS REDEVELOPMENT

SEATTLE, WASHINGTON

HUD SUBMITTAL

GGLO PROJECT NO. 2017033.00

VOLUME 2 – DIVISIONS 21-33

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DOCUMENT 000110

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DIVISION 33 – UTILITIES

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SECTION 210500

BASIC FIRE PROTECTION MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE OF THIS SECTION

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Compliance with all codes and standards applicable to this jurisdiction.
   2. Shop Drawings for Equipment
   3. Coordination Documents
   4. Record Drawings
   5. Start-up Service and Building Commissioning
   6. Instruction, Maintenance, and O & M Manuals
   7. Work associated with Delivery, Storage, and Handling of products
   8. Work associated with provision of Temporary Facilities
   9. Preparation of Posted Operating Instructions
   10. Meeting Project Safety and Indemnity requirements
   11. Proper Cleaning and Closing
   12. Supplying proper Warranty information
   13. Supply specified Guarantee documentation
   14. Design and provision of Supports and Anchors
   15. Pipe Portals
   16. Access Panels and Doors
   17. Identification Markers
   18. Coordination of Electrical requirements for equipment provided

1.2 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to provide all material and labor to install complete fire protection systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and he shall coordinate his work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the equipment, and risers and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing building and site systems, effort has been made to note existing utilities and services. However, the Contractor should thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

1.3 DESCRIPTION OF BID DOCUMENTS

A. Specifications:
   1. Specifications, in general, describe quality and character of materials and equipment.
   2. Specifications are of simplified form and include incomplete sentences.

1.4 DEFINITIONS

A. "Above Grade": Not buried in the ground and not embedded in concrete slab on ground.

B. "Actuating" or "Control" Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

C. "Below Grade": Buried in the ground or embedded in concrete slab on ground.

D. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

E. "Connect": Complete hook-up of item with required service.

F. "Exposed": Not installed underground or "concealed."

G. "Furnish": To supply equipment and products as specified.

H. "Indicated," "Shown" or " "Noted": As indicated, shown or noted on Drawings or Specifications.

I. "Install": To erect, mount and connect complete with related accessories.

J. "Motor Controllers": Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

K. "Must": A desire to complete the specified task. Allows some flexibility in application as opposed to "Shall."

L. “NRTL”: Nationally Recognized Testing Laboratory, including UL and/or ETL.

M. "Piping": Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

N. "Provide": To supply, install and connect as specified for a complete, safe and operationally ready system.

O. "Reviewed," "Satisfactory" or "Directed": As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner.

P. "Rough-In": Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

Q. "Shall": An exhortation or command to complete the specified task.

R. "Similar" or "Equal": Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

S. "Supply": To purchase, procure, acquire and deliver complete with related accessories.

T. “Typical” or “Typ”: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

U. "Will": A desire to complete the specified task. Allows some flexibility in application as opposed to "Shall."

V. "Wiring": Raceway, fittings, wire, boxes and related items.

W. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.5 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 21 Fire Suppression sections included herein.

B. Division 02: Existing Conditions.
   1. Coordination of excavation of trenches and the installation of piping on site.

C. Division 03: Concrete.
   1. All concrete work for Fire Suppression Division shall be included in Division 21 under the appropriate Sections and shall include:
      a. Concrete curbs and housekeeping pads for the equipment.
      b. Thrust blocks for piping.

D. Division 07: Thermal and Moisture Protection.
   1. Sealants and caulking.
   2. Firestopping.

E. Division 09: Finishes:
   1. Division 21 installers shall perform all painting, except where specifically stated otherwise in Division 09.

F. Division 26: Electrical is related to work of:
   1. Fire protection alarms and relays.
   2. Detectors and monitoring.
   3. Power connections to all equipment.
   4. Life safety provisions.

1.6 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 21 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

E. Provide in accordance with rules and regulations of the following:
   1. NFPA Standards:
      a. NFPA 13: Standard for Installation of Sprinkler Systems (Latest adopted version)
      b. NFPA 14: Standard for the Installation of Standpipe and Hose Systems (Latest adopted version)
      c. NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection (Latest adopted version)
      d. NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (Latest adopted version)
      e. NFPA 70: National Electrical Code (latest adopted version)
      f. NFPA 72: National Fire Alarm and Signaling Code (Latest adopted version)
      g. NFPA 101: Life Safety Code (Latest adopted version)
   2. Building Codes enforced by the Authority Having Jurisdiction in Washington:
      a. 2015 International Building Code (IBC) with State Amendments
      b. 2015 International Mechanical Code (IMC) with State Amendments

c. 2015 Uniform Plumbing Code (UPC) with State Amendments
d. 2015 International Fire Code (IFC) with State Amendment
e. 2015 International Fuel Gas Code, WAC 51-52
f. 2017 National Electrical Code (NEC)
g. 2015 Washington State Energy Code, (WAC 51-11, WSEC)

3. Local, city, county and state codes and ordinances
4. Local and State Fire Prevention Districts.
5. Other applicable standards and references:
   a. UL and FM Compliance: Provide products, which are UL listed and FM approved.
   b. ASCE/SEI 7-10: Minimum Design Loads for Buildings and Other Structures.
   c. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
   d. SMACNA: Seismic Restraint Manual-Guidelines for Mechanical Systems.
   e. Underwriters Laboratories, Inc.
   f. Industrial Risk Insurance Underwriters.
   g. Owner’s insurance agency.

F. Provide in accordance with appropriate referenced standards of the following:
1. NFPA - National Fire Protection Association.
2. CSA - Canadian Standards Association.
3. ANSI - American National Standards Institute.
4. ASME - American Society of Mechanical Engineers.
5. ASTM - American Society for Testing Materials.
6. AWS - American Welding Society.
7. AWWA - American Water Works Association.
8. MSS - Manufacturer's Standardization Society.
9. NEMA - National Electrical Manufacturer's Association.
10. UL - Underwriter's Laboratories.
11. ADA - Americans with Disabilities Act.
12. ETL - Electrical Testing Laboratories.
13. IAPMO - International Association of Plumbing and Mechanical Officials.

1.7 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be aluminum or Type 304 stainless steel sheet, not less than 20 USG (0.0375”), riveted or bolted to the manufactured item, with nameplate data engraved or punched to form a non-erasable record of equipment data.

B. Current Models. All work shall be as follows:
1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

C. Experience: Unless more stringent requirements are specified in other sections of Division 21, manufactured items shall have been installed and used, without modification, renovation or repair, on other projects for not less than one year prior to the date of bidding for this project.

D. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.
1. All pipe, pipe fittings and valves shall be manufactured in North America. Alternatives may be acceptable, but must be submitted and approved by the Owner’s Representative prior to bidding.

E. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in

hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

1.8 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permits, licenses, fees and inspections.

D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access.

E. Coordinate equipment and materials installation with other building components.

F. Verify all dimensions by field measurements.

G. Arrange for chases, slots, and openings in other building components to allow for installations.

H. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

I. Sequence, coordinate, and integrate installations of materials and equipment for efficient flow of the work.

J. Coordinate the cutting and patching of building components to accommodate the installation of equipment and materials. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted.

K. Install fire protection services and overhead equipment to provide the maximum headroom possible.

L. Install equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

M. Coordinate the installation of materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, and other installations.

N. Coordinate connection of systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

O. Coordinate with Owner's Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

P. All materials (such as insulation, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

Q. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

1.9 MINOR DEVIATIONS

A. The Contractor shall review the structural and architectural conditions and drawings affecting his work. It is the specific intention of this section that the contractor's scope of work shall include
   1. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications

B. The Contractor shall study the operational requirements of each system, and shall arrange his work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems from the physical space available for use by this section. This requirement extends to the Contractor's coordination of this section's work with the "Electrical Work." Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

C. Advice the Owner’s Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.

1.10 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:
   1. The proposed substitution does not affect dimensions shown on drawings.
   2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
   3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
   4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.11 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner’s Representative for approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Submittals and Shop Drawings:

1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner's Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.

2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.

3. Paper submittals will only be acceptable if specifically required by Division 01.

4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.12 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.

1. The shop drawings shall serve to record the coordination of the installation and location of all fire sprinkler heads, piping, HVAC equipment, ductwork, grilles, diffusers, lights, audio/video systems, electrical services and all system appurtenances.

2. The Drawings shall include all mechanical rooms and floor plans.

3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner's Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner's Representative.

4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:

1. Two dimensional AutoCAD / Revit based documents:

a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.

b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the HVAC work.

c. Fire protection drawings shall indicate locations of all sprinkler heads and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.

d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.

e. Drawings shall incorporate all addenda items and change orders.

f. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner's Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

1.13 REQUESTS FOR INFORMATION (RFIS

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).
1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
2. RFIs shall address single questions and related issues only.
3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect and Construction Manager.
6. RFI number, numbered sequentially and unique.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.
   1. The following Contractor-generated RFIs will be returned without action:
      a. Incomplete RFIs or inaccurately prepared RFIs.
      b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
      c. RFIs addressing multiple unrelated issues.
      d. Requests for approval of submittals.
      e. Requests for approval of substitutions.
      f. Requests for approval of Contractor's means and methods.
      g. Requests for information already indicated in the Contract Documents.
      h. Requests for adjustments in the Contract Time or the Contract Sum.
      i. Requests for interpretation of Engineer's actions on submittals.
   2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.14 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked "Record Set" at the job site at all times, and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping, size and location both exterior and interior; including control devices, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance.

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. At the completion of the construction transfer all "Record Set" notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

E. Refer also to Division 01 for full scope of requirements.

1.15 START-UP SERVICE AND BUILDING COMMISSIONING

A. Prior to start-up, be assured that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of pumps, and other major pieces of equipment. Certify in writing compliance with this Paragraph, stating names of personnel involved and the date work was performed.

C. Refer to other Division 21 Sections for additional requirements.

1.16 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. O&M Manuals: Upon completion of the work, the Contractor shall submit to the Owner's Representative complete set of operating instructions, maintenance instructions, part lists, and all

other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section, bound in a durable binder. Refer to Division 01.

B. The Contractor shall be responsible for proper instruction of Owner's personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 21 to be no less than 2 hours for each piece of equipment.

1.17 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment showing signs of rust shall be removed from site and replaced with new.

1.18 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.19 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.

B. No act, service, Drawing, review, or Construction Review by the Owner, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.20 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner’s Representative.

1.21 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, defined as starting from the date of Certificate of Occupancy, and shall include all parts, material, labor and travel.

D. Refer to individual Specification sections for additional extended warranty requirements.

E. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

F. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

G. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.22 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after the Certificate of Occupancy, ordinary wear and tear excepted. The guarantee shall include parts, shipping, labor, travel costs, living expenses, required fees, and any other associated cost or expense to repair or replace products or systems.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

2.2 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:

1. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.
2. Manufacturers: Hilti Inc., B-Line, Anvil International, Tolco, Kin-Line, Simpson, Erico or Superstrut.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS types listed.
1. Adjustable Steel Clevis Hangers: MSS Type 1.
2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
3. U-Bolts: MSS Type 24.
4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
   a. Plate: Unguided type.
   b. Plate: Guided type.
   c. Plate: Hold-down clamp type.
5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
8. Single Pipe Roller with Malleable Sockets: MSS Type 41.
9. Adjustable Roller Hangers: MSS Type 43.
10. Pipe Roll Stands: MSS Type 44.
11. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp or equal.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.
1. Steel Turnbuckles: MSS Type 13.
2. Steel Clevises: MSS Type 14.
3. Swivel Turnbuckles: MSS Type 15.
4. Malleable Iron Eye Sockets: MSS Type 16.
5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated, provide factory-fabricated building attachments of one of the following types listed.
1. Concrete Inserts: HCI-MD (for metal deck) or HCI-WF (for wood forms) cast-in anchors by Hilti Inc. or MSS Type 18 or Blue Banger Hanger by Simpson
2. Steel Brackets: One of the following for indicated loading:
   a. Light Duty: MSS Type 31.
   b. Medium Duty: MSS Type 32.
   c. Heavy Duty: MSS Type 33.
3. Horizontal Travelers: MSS Type 58.
4. Concrete Screw Anchors: Hilti Kwik HUS EZ or equal.
5. Torque-Controlled Expansion Anchor: Hilti Kwik Bolt TZ or equal.

G. Saddles and Shields (for heat traced pipe): Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
   1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
   2. Insulation Protection Shields: MSS Type 40, 18” minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
   3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert.
   4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain tubing and join insulation at clevis hangers and strut-mounted clamps. Klo-Shure Insulation Coupling or equal.

H. Miscellaneous Materials:
   1. Metal Framing: Provide products complying with NEMA STD ML1.
   2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
   3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand by volume, with minimum amount of water required for placement and hydration.
   4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.
   5. Pipe Brackets: "HoldRite" copper plated brackets. Insulate brackets attached to metal studs with felt.

2.3 SEISMIC RESTRAINT/VIBRATION ISOLATION REQUIREMENTS

A. Equipment, piping, and all system appurtenances (including weight of normal operating contents) shall be adequately restrained to resist seismic forces. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest code editions with State Amendments, applicable local codes, and applicable Importance Factors and Soil Factors. Refer to Section 210548 Vibration Isolation for Fire Protection Equipment or Section 210549 Seismic Restraint for Fire Protection Piping and Equipment, as applicable.

2.4 ACCESS PANELS AND ACCESS DOORS

A. Provide all access doors and panels to serve equipment under this work, including those which must be installed, in finished architectural surfaces. Frame of 16-gauge steel, door of 20 gauge steel. 1” flange width, continuous piano hinge, key operated, prime coated. Refer to Architectural Specifications for the required product Specification for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels are not shown on Plans. Access doors shall be of a size to permit removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each concealed valve. Use no panel smaller than 12" x 12” for simple manual access, or smaller than 24" x 24" where personnel must pass through. Provide cylinder lock for access door serving mixing or critical valves in public areas.

B. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to serve equipment under this work and in the proper sequence to keep in tune with construction and with prior approval of the Owner’s Representative. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.

C. Acceptable Manufacturers: Milcor, Karp, Nystrom, Elmdor/Stoneman, or equal.

D. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner's Representative.

2.5 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 21 Sections. Where more than a single type is specified for application, selection is at installer's option, but provide single selection for each product category. Stencils are not acceptable.

B. Plastic Pipe Markers:
1. Snap-On Type: Provide pre-printed, semi-rigid snap-on, color coded pipe markers, complying with ANSI A13.1.
2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape.
3. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

C. Underground-Type Plastic Line Markers: Provide 6" wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.

D. Valve Tags:
1. Brass Valve Tags: Provide 1 1/2" diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener. Fill tag engraving with black enamel.
2. Plastic Laminate Valve Tags: Provide 3/32" thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32" hole for fasteners.
3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.
4. Access Panel Markers: Provide 1/16" thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8" center hole to allow attachment.

E. Plastic Equipment Signs:
1. Provide 4-1/2" x 6" plastic laminate sign, ANSI A.13 color coded with engraved white core lettering.
2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters, such as pressure, rpm, etc.

F. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Inc., Brimar or equal.

2.6 ELECTRICAL

A. General:
1. All electrical material, equipment, and apparatus specified herein shall conform to the requirements of Division 26.

2. Provide all motors for equipment specified herein. Provide motor starters, controllers, transfer switches, and other electrical apparatus and wiring which are required for the operation of the equipment specified herein.
3. Set and align all motors and drives in equipment specified herein.
4. Provide expanded metal or solid sheet metal guards on all V-belt drives to totally enclose the drive on all sides. Provide holes for tachometer readings. Support guards separately from rotating equipment.
5. Provide for all rotating shafts, couplings, etc., a solid sheet metal, inverted "U" cover over the entire length of the exposed shaft and support separately from rotating equipment. Cover shall extend to below the bottom of the shaft and coupling, and shall meet the requirements of the State Industrial Safety Regulations.
6. Specific electrical requirements (i.e., horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

B. Quality Assurance:
1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for location and use - no exceptions.

C. Low Voltage Control Wiring:
1. General: 14 gauge, Type THHN, color coded, installed in conduit.
2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp., Senator Wire and Cable Co., Southwire Co, or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master fitter and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work, unless so indicated on Drawings or approved by Owner’s Representative.

3.2 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.3 INSTALLATION

A. Coordinate the work between the various Fire Protection Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision or failure to make proper and timely provisions, the alternations shall be made to the satisfaction of the Owner’s Representative and at the Contractor’s cost. Coordinate wall and ceiling work with the General Contractor, and his subcontractors in locating ceiling air outlets, wall registers, etc.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defected materials.

3.4 SUPPORTS AND HANGERS

A. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides,

strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms.

B. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

C. Install hangers, supports, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

D. Install hangers within 12 inches of every change in piping direction, end of pipe run or concentrated load, and within 36 inches of every major piece of equipment. Hangers shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one hanger is required.

E. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

F. Support sprinkler piping independently of other piping.

G. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

H. Hanger Spacing in accordance with following minimum schedules (other spacings and rod sizes may be used in accordance with NFPA):
   1. Steel Pipe:

Pipe Size	Max. Hanger Spacing	Rod Size
1/2" to 1-1/4"	5 feet	3/8"
1-1/2" to 2"	7 feet	3/8"
2-1/2" to 3"	10 feet	1/2"
4" and larger	12 feet	5/8"

I. Sloping, Air Venting, and Draining:
   1. Slope all piping as specified and as indicated, true to line and grade, and free of traps and air pockets. Unless indicated otherwise, slope piping in the direction of flow as follows:

Service	Slope
Wet	Not required
Dry Mains	1/4"/10'
Dry Branches	1/2"/10'

J. Provisions for Movement:
   1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
   2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.

K. Installation of Anchors:

1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends.

L. Equipment Supports:
1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction.
2. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.

M. Adjusting:
1. Hanger Adjustment: Adjust hangers so as to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5 PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades they are installed when roofing is being installed.

3.6 VIBRATION CONTROL ISOLATORS

A. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

B. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

C. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

D. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

F. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.7 ELECTRICAL COORDINATION

A. Division 21 installers shall coordinate with Division 26 work to provide complete systems as required to operate all mechanical devices installed under this Division of work.

B. Installation of Electrical Connections: Furnish, install, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, etc., motors and controls in accordance with the drawings and in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC, and NECA's "Standard of Installation" to ensure that products fulfill requirements.

C. Division 21 has responsibilities for electrically powered fire protection equipment which is specified in Division 21 Specifications or scheduled on Division 21 Drawings as follows:
   1. Motors: Furnish and install all motors necessary for mechanical equipment.
   2. Magnetic Starters: Furnish all magnetic starters whether manually or automatically controlled which are necessary for mechanical equipment. Furnish these starters with all control relays or transformers necessary to interface with mechanical controls. If the starter is factory installed on a piece of Division 21 equipment, also furnish and install the power wiring between starter and motor.
   3. Variable Frequency Drives: Provide all VFD's associated with fire protection equipment. If the drive is installed on a piece of factory assembled equipment the wiring between motor and drive is to be provided as part of the factory equipment.
   4. Disconnects: Provide the disconnects which are part of factory wired Division 21 equipment. Factory wiring to include wiring between motor and disconnect or combination starter/disconnect.
   5. Controls: Division 21 Contractor (including the Building Automation System (BAS) Controls subcontractor) is responsible for furnishing the following equipment in its entirety. This equipment includes but is not limited to the following:
      a. Control relays necessary for controlling Division 21 equipment.
      b. Control transformers necessary for providing power to controls for Division 21 equipment.
      c. Low or non-load voltage control components.
      d. Non-life safety related valve or damper actuators.
      e. Float switches.
      f. Solenoid valves, EP and PE switches.
      g. Communications wiring and conduit between control devices and fire protection equipment.
      h. Raceway to support control cabling.

D. Division 26 Electrical Responsibilities:
   1. Motors: Provide the power wiring for the motors from servicing panel to motor controller.
   2. Magnetic Starters: Except where magnetic starters are factory installed on Division 21 factory assembled equipment, Division 26 is to install magnetic starters furnished by Division 21 and install the necessary power wiring to the starter and from the starter to the motor. In the case of factory installed starters, Division 26 is to install the necessary power wiring from source panel/disconnect to the starter.
   3. Variable Frequency Drives: Provide the necessary power wiring to the VFD and from the VFD to the motor except in the case of factory installed VFD's where wiring between the motor and VFD is to be by Division 21.
   4. Disconnects: Provide all disconnects necessary for Division 21 fire protection equipment which are not provided as part of factory wired Division 21 equipment. Provide power wiring to all disconnects. In addition, provide power wiring between motor and disconnect when the disconnect is not factory installed.
   5. Controls: Division 26 is responsible for providing power to control panels and provide final power connection to Division 21 provided control transformers.

6. Fire Sprinkler System: Division 26 is responsible for providing power wiring to fire protection controls including flow switches and alarm bells.
7. Specialized fire suppression systems: Division 26 is responsible for providing power wiring to suppression system and its controls.

E. Motors and Motor Control Equipment: Conform to the standards of the NEMA. Equip motors with magnetic or manual line starters with overload protection. Motor starters and line voltage controls shall be installed under Electrical Section but located and coordinated as required under this Section of the work. Starters shall be combination type with non-fusible disconnect switches. All single phase fractional horsepower motors shall have built-in overload protection.

3.8 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Piping System Identification:
1. Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.
2. Locate pipe markers as follows:
   a. Near each valve and control device.
   b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
   c. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
   d. At access doors, manholes, and similar access points which permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Spaced horizontally at maximum spacing of 20' along each piping run, with minimum of one in each room. Vertically spaced at each story traversed.

C. Underground Piping Identification: During backfilling/topsoiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over buried line at 6” to 8” below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16”, install single line marker.

D. Equipment Identification: Locate engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device. Provide signs for the following:
1. Main control and operating valves, including safety devices.
2. Meters, gauges and similar units.
3. Pumps, compressors, and similar motor-driven units.
4. Sprinkler and standpipe equipment.

E. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.

3.9 VIBRATION AND DYNAMIC BALANCING

A. Vibration tolerances shall be as specified by the "International Research and Development Corporation", Worthington, Ohio, measured by the displacement, peak to peak, as follows:
1. Pump and Electric Motors: Below severity chart labeled "SLIGHTLY ROUGH", maximum vibration velocity of 0.157 in/sec, peak.
2. Compressors: Same as pumps.

B. Correction shall be made to all equipment which exceeds vibration tolerances specified above. Final vibration levels shall be reported as described above.

3.10 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner's Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

END OF SECTION 210500

SECTION 211000

FIRE PROTECTION

PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 210500 - Basic Fire Protection Materials and Methods, and other Sections in Division 21 specified herein.

1.2 DEFINITIONS

A. Pipe sizes used in this Section are nominal pipe size (NPS) specified in inches.

B. Working plans as used in this Section refer to documents (including drawings and calculations) prepared pursuant to requirements in NFPA 13 for obtaining approval of authority having jurisdiction.

C. NICET - National Institute for Certification In Engineering Technologies

D. Other definitions for fire protection systems are included in referenced NFPA standards.

1.3 DESCRIPTION OF WORK

A. The work includes designing, providing and installing a complete and fully operable automatic sprinkler system as described in this Section of the Specification and as shown on the contract construction drawings and shall be in accordance with rules, regulations and standards as required by the authorities having jurisdiction.
   1. State.
   2. City.
   3. Building Department.
   4. Fire Prevention Division, Fire Marshal’s Office.

B. Work includes but is not limited to the following:
   1. Automatic Wet Type Sprinkler System.
   2. Standpipes.
   3. Areas Subject to Freezing Temperatures: Dry Type Sprinkler System.
   4. Standpipes in Areas Subject to Freezing Temperatures: Dry type.
   5. Fire Pump system
   6. All cutting and patching.
   7. Provide all pipe, fittings, sprinklers, valves, signs, flow switches, tamper switches, protective painting, test connections, drains and tests necessary to make the entire system complete and operative.
   8. Coordinate with plumbing contractor for capacity of all sprinkler main, test, and auxiliary drain connections.
   9. Valve tags and instruction plates shall be mounted and/or hung per local fire department requirements.
   10. All required fire extinguishers.
   11. All sleeves and inserts.
   12. 3" drain riser shall be provided adjacent to each standpipe riser for testing and draining.
   13. Provide hose valve with cap downstream of sprinkler system pressure reducing valves for the purpose of testing. Hose valve shall be sized to provide full flow through pressure reducing valve.
   14. All trenching and backfilling, including culverts under rails and guard posts where required.

1.4 SUBMITTALS

A. Product Data: Submit six copies of manufacturer's technical data and installation instructions for fire protection materials and products.
   1. Thirty days after the awarding of contract, contractor shall submit list of manufacturer's names and model numbers for review and comment to Owner's Representative. This list shall identify any prior approved substituted items contractor wishes to use. Do not submit technical data until list has been approved.
   2. Prior to construction submit for review and comment items including but not be limited to the following:
      a. Coordinated layout drawings. Lettering shall be minimum 1/8" high.
      b. Sprinklers and escutcheons - designating area of use.
      c. Valves, valve boxes, flow switches, and tamper switches.
      d. Provide Fire Marshal approval numbers for flow switches and tamper switches.
      e. Pipe, fittings, sway bracing, inserts, anchors and hangers.
      f. Inspector's test and drain station.
      g. Fire department connections.
      h. Fire extinguishers.
      i. Hose valves, pressure relief valves, and pressure reducing valves.
      j. Fire pumps with performance curve.
      k. Fire hydrants.

B. Working Plans: Prepare scaled working plans for fire protection pipe and fittings including, but not necessarily limited to, pipe and tube sizes, locations, and elevations and slopes of horizontal runs, wall and floor penetrations, and connections. Indicate interface between and spatial relationship to piping and adjacent equipment. Lettering shall be minimum 1/8" high.
   1. Spacing of fire sprinklers shall be coordinated with lights, air conditioning outlets, sound speakers, architectural reflected ceiling plan; obstruction from light fixtures and other architectural features; and sprinkler piping shall be coordinated with HVAC ductwork & piping, plumbing, electrical conduit, cable trays and structure prior to the installation. Drawings shall be composite type including mechanical, plumbing and lighting equipment with sprinkler and sprinkler drain piping.

C. Submittal Drawings: Submit shop drawings to Agency having jurisdiction for approval bearing engineer of record stamp bearing preparer's NICET stamp. Submit six approved copies, bearing stamp and/or signature of authority having jurisdiction to the Owner's Representative for review and comment.
   1. Contractor shall submit sprinkler head locations to architect for approval.
   2. Each calculation shall include legible schematic of system showing all hydraulic reference points.

D. Hydraulic Calculations: Prepare hydraulic calculations of fire protection systems. Submit to authority having jurisdiction for approval. Submit six approved copies, bearing stamp, and/or signature of Agency having jurisdiction to Owner's Representative for review and comment.
   1. Contractor shall submit published piping friction loss data from manufacturer with hydraulic calculations.

E. Certificate of Installation: Submit certificate upon completion of fire protection piping work, which indicates that work has been tested in accordance with NFPA 13, and also that system is operational, complete, and has no defects.

F. Maintenance Data: Submit maintenance data and parts lists for fire protection materials and products. Include this data, product data, shop drawings, approval drawings, approval calculation, certificate of installation, and record drawings in maintenance manual; in accordance with requirements of the General Conditions and of Division 01.

G. Operating and Maintenance Instructions: Provide the Owner with three sets of operating and maintenance instructions covering completely the operation and maintenance of sprinkler equipment and controls. Manual shall be assembled in a 3-ring binder and arranged in following sections:
   1. Site Utilities: Drawings showing location, size, depth of all connections, valve boxes, manholes, etc., as installed.
   2. A chart tabulating all types of pipe fittings, valves, and piping specialties installed in each system.
   3. A chart tabulating all pressures, valve settings for fire department and sprinkler pressure reducing valves. Provide pressure reducing valve flow test documentation.
   4. Manufacturer's brochures of all sprinkler heads.
   5. Manufacturer's brochures of fire pumps, jockey pump and controllers.
   6. Tamper switches and flow switches.
   7. Fire Department connections.
   8. Fire Extinguishers.
   9. Fire Hydrants.
   10. Reproducible copies of approved working drawings prepared to facilitate the actual installation of ductwork and piping. Drawings shall indicate location of all concealed valves, and other apparatus.
   11. Copy of NFPA 25 "Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems."
   12. Approval Calculations.
   13. Certificate of Installation.
   14. Guarantees.
   15. The Contractor is responsible for proper instruction of Owner's personnel for operation and maintenance of all material, equipment and apparatus provided.

1.5 DESIGN DESCRIPTION

A. This section of the specification combined with any of the contract drawings are intended as a guide to establish a basis of design for the systems required.

B. Contractor shall examine the existing conditions, the Architectural, Interior Design, Structural, Mechanical and Electrical drawings, layout and install a completely hydraulically sized sprinkler system for all areas. Space shall be provided for any valving and equipment to be used.
   1. System shall start 5'-0" from perimeter wall and extend throughout the building. Fire main beyond 5'-0" perimeter is provided under Division 02 work. System shall start at connection to utility main, with double detector check backflow prevention assembly, and extend throughout the building.
   2. Contractor shall contact Owner’s insurance agency to incorporate insurer’s design requirements in this layout document. Factory Mutual may review layout drawings and calculations. Incorporate all of their design criteria into documents.

C. Base Building construction shall include upright heads with tees with 1” outlets for future drop in areas with no ceiling. Areas with ceilings, including finished core areas, lobbies, corridors or as noted herein shall have concealed [recessed pendent] heads installed as part of the base building construction. Unfinished areas shall be provided with upright type heads. Heads will be relocated to the finished ceiling tile under the tenant improvement contract.

D. All areas shall be sprinklered as the construction progresses, including accessible pipe chases, elevator hoistways, etc.

E. Install dry type standpipe risers in each of the stairwells with fire department valves on each floor level. Provide 500 gpm at 100 psig or 65 psig at most remote fire department valves. Fire department valves not in stairwell shall be housed in cabinets. Provide roof manifold at top of each standpipe.

F. Fire pumps shall be installed to maintain minimum pressures as required by the local authority having jurisdiction and NFPA Pamphlets 13 and 14. Fire pumps shall be furnished and installed in accordance with NFPA Pamphlet No. 20.

G. Pressure restricting devices shall be installed on any branch outlet exceeding 100 psi.

H. All electrical devices used for this system shall be compatible with the fire alarm system, refer to Division 26.

1.6 HYDRAULIC DESIGN

A. System shall be a straight line or gridded system per NFPA No. 13 with the following exceptions:
1. For all systems the design area shall be the hydraulically most demanding rectangular area.
2. Minimum pressure for any sprinkler head shall not be less than 7 psi.
3. Velocity in fire pump suction piping shall not exceed 15 feet per second.

B. Fire Standpipes: Pipe schedule per IBC, Chapter 9 or hydraulically calculated at 500 GPM for first standpipe and 250 GPM for each additional standpipe. Wet standpipes shall maintain 65 psig (minimum) at top of each riser.

C. Total Combined Inside & Outside Hose Allowances: Hydraulic calculations shall include an allowance for hose streams, added at the point of connection to the water supply.

D. Safety Factor: 10 psi, or 10 percent of static and residual pressure, whichever is greater.

E. Sprinkler system Occupancy Hazard Classifications shall be approved by authorities having jurisdiction:
1. Building Service Areas: Ordinary Hazard, Group 1
2. Electrical Equipment Rooms: Ordinary Hazard, Group 1
3. General Storage Areas: Ordinary Hazard, Group 1
4. Mechanical Equipment Rooms: Ordinary Hazard, Group 1
5. Residential Living Areas: Light Hazard

F. Minimum Density for Automatic-Sprinkler Piping Design shall comply with the following:
1. Light Hazard Areas: Water density of 0.10 GPM per square foot calculated for an area of 1500 square feet in the most remote location.
2. Ordinary Group I Hazard Areas: Water density of 0.15 GPM per square foot calculated for an area of 1500 square feet in the most remote locations.
3. Ordinary Group II Hazard Areas: Water density of 0.20 GPM per square foot calculated for an area of 1500 square feet in the most remote locations.

G. Head spacing shall not exceed the limits described in NFPA Pamphlet No. 13.
1. Light Hazard: 225 sq.ft. (for smooth ceiling).
2. Ordinary Hazard: 130 sq. ft.

H. Maximum floor areas protected by any one sprinkler system riser:
1. Light Hazard: 52,000 sq.ft.
2. Ordinary Hazard: 52,000 sq.ft.

I. Flow Data: Contractor is to verify flow data (static pressure, residual pressure and GPM flowing) available at site and provide design for available pressure and flow.

1.7 RELATED WORK SPECIFIED ELSEWHERE

A. Section 210500: Basic Materials and Methods

B. Section 210549: Seismic Restraint for Fire Protection Piping and Equipment

C. Division 26: Electrical. Coordinate for electrical wiring of detectors, flow alarm switches, tamper switches, fire alarm bell, for electrical wiring of fuel oil and water tank level alarms, connection by life safety section for remote monitoring <<and starting>> of fire pump, and power to fire pumps. All electrical devices used for this system shall be compatible with the fire alarm system. Coordinate with electrical for electric fire pump motor size and emergency generator sizing.

D. Division 09: Finishes.

E. Division 02: Existing Conditions. Coordinate with General Contractor for excavation for the underground water supply system.

F. Coordination with Architectural for fire protection water supply tank.

G. Coordination with Mechanical for diesel exhaust.

H. Coordination with Mechanical for fuel oil day tank piping.

I. Division 22: Coordination with Plumbing for drain.

1.8 QUALITY ASSURANCE

A. The Contractor for the fire protection installation shall be duly qualified Fire Protection Contractor, experienced and regularly engaged in the installation of fire protection systems with a license classification of C-16. Where local authorities require additional licensing of the Fire Protection Contractor, and/or workmen, such a license shall be mandatory for a prospective Contractor.
   1. Contractor is to verify flow data (static pressure, residual pressure and GPM flowing) available at site and provide design for available pressure and flow.
   2. The Fire Protection contractor shall be the Engineer of Record for the automatic sprinkler and standpipe system.
   3. Permits - The Fire Protection Contractor shall obtain permits for the installation or construction as required for approval and installation of the fire protection system. The Fire Protection Contractor shall submit working plans to the authorities having jurisdiction to obtain approval.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01. Handle components carefully to prevent damage, denting, and scoring. Do not install damaged components. Damaged components shall be replaced with new components.

B. Store/protect products under provisions of Division 01. Store components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage.

1.10 WARRANTY – ADDITIONAL REQUIREMENTS

A. Refer to Section 220500 for basic warranty requirements.

B. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak. .

PART 2 - PRODUCTS

2.1 GENERAL

A. All products to be commercial grade, new and of the manufacturer's latest design model. Products manufacturers outside of North America will not be accepted without written approval from engineer prior to submission of bid.

B. All products to be UL listed and/or FM approved, except for items, which are not required to be listed by code.

C. All products shall be delivered and stored in original containers. Containers shall be clearly marked or stamped with manufacturer's name and rating.

D. The following items to be included but specified under Section 210500: Basic Fire Protection Materials and Methods.
1. Hangers and supports.
2. Escutcheons plates, flashings and sleeves.
3. Access panel and doors.
4. Identification markers and signs.
5. Expansion compensators and flexible connectors.
6. Anchors, and seismic restraints.
7. Excavation and backfill.

2.2 PIPE AND FITTINGS - ABOVE GROUND

A. General: The piping products listed below by manufacturer's name and model numbers are the only acceptable materials listed for this project. Substitutions of pipe must be submitted and approved in writing by the architect prior to bid. No copper pipe shall be allowed in the wet fire sprinkler system.

B. Piping or fittings that show substantial rust or breaks in coating will be removed and replaced.

C. Steel Pipe and Fittings for wet systems:
1. Standard-Weight, Galvanized- and Black-Steel Pipe: ASTM A53/A53M. Pipe ends may be factory or field formed to match joining method.
2. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
3. Thinwall Galvanized- and Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA-13 specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
5. Galvanized- and Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.
6. Galvanized- and Uncoated-Steel Couplings: ASTM A865/A865M, threaded.
7. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
8. Malleable- or Ductile-Iron Unions: UL 860.
9. Cast-Iron Flanges: ASME 16.1, Class 125.
10. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
    a. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
    b. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
    c. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
    d. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
11. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.
    a. 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.
    b. Shop-weld thread-o-lets may be used in lieu of tee fittings, but field (site) welding will not be permitted.

12. Grooved-Joint, Steel-Pipe Appurtenances:
    a. Pressure Rating: 175-psig (1200-kPA) minimum, and as required by the design.
    b. Galvanized, Painted, or Uncoated Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
    c. 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.
    d. Mechanical Couplings: Victaulic grooved couplings style 07, 75 or 77, or equal by Gruvlok.
    e. Mechanical Tees: Victaulic style 920, Gruvlok. U-bolt mechanical tees are not acceptable.
    f. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
    g. Use rigid couplings where flexibility is not required or provide necessary sway bracing.

D. Dry Standpipe, Dry Sprinkler and Pre-Action Sprinkler Piping and Fittings:
    1. Schedule 40 galvanized steel, ASTM A123.
    2. Pipe ends may be factory or field formed to match joining method.

E. Flexible sprinkler connector for ductwork sprinkler application: Flexhead or equal Factory Mutual approved system.

F. Piping and Fittings – Not Allowed:
    1. Pipe that is lighter gauge than Schedule 30 with threaded fittings is not allowed.
    2. Schedule 5 piping and fittings are not allowed.
    3. Threadable lightwall pipe is not allowed.
    4. Mechanical “gripping teeth” type fittings are not allowed.
    5. Mechanical “clamping” type tee fittings are not allowed.
    6. Quick disconnect, boltless, snap-joint, field drilling or welding of any main or branch lines, and any device specifically prohibited by the local authority having jurisdiction is not allowed.
    7. Unions are not allowed for any size pipe.
    8. Plain end fittings are not allowed.

2.3 PIPE AND FITTINGS - UNDERGROUND

A. Class 52 ductile iron pipe and fittings, white, cement lined, mechanical or Tyton joint fittings. Piping to be factory encased with 8 mil polyethylene tube or sheet. Fittings to be double field wrapped with 2" wide, 20 mil vinyl tape, 50% overlap.

B. Manufacturer: United States Pipe and Foundry, Griffin or Pacific States, only.

C. Polyvinyl Chloride (PVC) Plastic Pipe:
    1. Pipe and fittings: Pipe shall conform to AWWA C900 and shall be plain end or gasket bell-end, pressure Class 150 with cast-iron-pipe-equivalent OD. Fittings shall be gray-iron or ductile-iron conforming to AWWA C110, and shall have cement lining conforming to AWWA C104, standard thickness.
    2. Joints and Jointing Material: Joints for pipe shall be push on joints as specified in ASTM D3139. Joints between pipe and metal fittings, valves, and other accessories shall be push on joints as specified in ASTM D3139 or shall be compression type joints / mechanical joints as respectively specified in ASTM D3139 and AWWA C111. Provide each joint connection with an elastomeric gasket suitable for bell or coupling or push-on joints with which it is to be used.
    3. Transition from PVC to ductile iron pipe shall occur a minimum of 5 feet from building.

D. All underground piping for fire mains shall be installed, clamped, anchored, flushed and hydrostatically pressure tested according to the requirements of the authorities and/or agencies having jurisdiction, and NFPA Pamphlets Nos. 13 and 24 and F. M. Handbook of Industrial Loss Prevention.

E. Anchor underground riser stub to nearest underground connection by means of rodding. Retaining glands with setscrews above grade are not allowed.

2.4 UNDERGROUND PIPE COATING:

A. All underground ferrous piping shall be covered with:
1. Either two coats of 10 Mill Scotch Wrap No. 51, or with;
2. "XTRU-COAT" prefabricated extruded cover with joints sealed with two coats of 10 Mill Scotch Wrap #51.
3. Or approved equal

2.5 THRUST BLOCKS

A. Provide thrust blocks at changes in pipe direction, changes in pipe sizes, dead-end stops and at valves.

B. Calculate area of undisturbed earth of thrust block based on actual soil conditions and water test pressure of 200 psi.

C. Concrete and reinforcing steel shall be as specified in Division 03 and 05. All concrete shall be Class A, unless specified otherwise.

D. Miscellaneous nuts and bolts shall be stainless steel.

2.6 RODS AND CLAMPS

A. Socket clamps shall be stainless steel; four bolt type, equipped with stainless steel socket clamp washers and nuts Grinnell Fig. 595 and 594, Elcen Fig. 37 and 37X, or equal.

B. Rods shall be stainless steel, 3/4" diameter.

2.7 SPRINKLER HEADS - GENERAL

A. Sprinkler heads shall be regular automatic closed-type heads of ordinary degree temperature rating except that sprinkler heads installed in the vicinity of heating equipment or in special occupancy areas shall be of the temperature rating as described in NFPA No. 13.

B. Provide quick response heads in all new light hazard occupancies.

C. Provide corrosion-resistant sprinkler heads where they are exposed to weather, moisture or corrosive vapors.

D. The Contractor shall furnish spare heads. The heads shall be packed in a suitable container and shall be representative of, and in proportion to, the number of each type and temperature rating head installed. In addition to the spare heads, the contractor shall furnish not less than two special sprinkler head wrenches. Refer to NFPA 13 section; "Stock of Spare Heads".

E. Provide 1” clearance with escutcheon around penetrations through suspended ceilings per ASCE requirements.

2.8 SPRINKLER HEADS AND ESCUTCHEONS

A. Sprinkler heads installed shall be upright or pendent, as conditions require, and shall be of the following type and finish for the areas designated. Unless otherwise specified, sprinklers shall be small frame type, center bulb capsule for finished areas, fusible link for unfinished areas, and 1/2" orifice. Extended coverage sprinkler heads are not allowed.

BUILDING AREA	SPRINKLER HEAD STYLE	SPRINKLER HEAD FINISH	ESCUTCHEON FINISH	TEMPERATURE RATING (°F)
Unfinished Space, Exposed Ceiling Retail, Exposed Ceiling Office, Parking Structure, Mechanical Rooms	Upright/Pendant	Brass	None	155°F
Electrical, Telephone & Switchgear Rooms	Upright	Brass	None	286°F
Finished Ceilings	Semi-recessed Pendant	White	White	155°F
Finished Ceilings in Conference Rooms and Lobbies	Concealed Pendant	Brass	White Cover Plate	155°F
Soffit	Flush Sidewall	White	White	155°F
Sidewall	Horizontal Sidewall	Brass	None	155°F
Exterior Balconies & Overhangs	Dry Sidewall	Brass	Chrome	175°F

B. Manufacturer: Tyco, Reliable, Viking, Globe, Victaulic, Venus or equal.

2.9 VALVING

A. 2" or Smaller:
1. Control Valve: OS&Y rising stem type gate valve bronze body, bonnet and disc, copper alloy stem, threaded ends, 175 psig WOG min. Provide with tamper switch.
2. Check Valve: Swing check type with bronze body, cap and disc, threaded ends, 175 psig WOG min.
3. Drip Valve: 3/4", cast brass automatic ball drip type, threaded ends, 175 psig WOG min.
4. Testing Valve: 1-1/4", test and drain, sight glass, ½" test orifice, lever operated, 300 psig WOG. Drain to mop sink or drain riser.
5. Main Drain Valve: 2", angle gate valve, bronze body, copper alloy stem, threaded ends, 175 psig WOG. Drain to mop sink or drain riser.

B. 2-1/2" or Larger:
1. Control Valve: Grooved butterfly valve with tamper switch, ductile iron body, aluminum bronze disc, stainless steel stem and EPDM Liner, 200 psig WOG min, Victanlic 700.
2. Control Valve: OS&Y rising stem type gate valve, cast iron body and bonnet, bronze stem, seat and disc, flanged ends, 175 psig WOG min. Provide with tamper switch.
3. Check Valve: Swing check type with cast iron body, bolted cap and disc, flanged ends, 175 psig WOG min.
4. Manufacturer: Grinnell, Stockham, Milwaukee, Mueller, Kennedy, Elkart or AGF.

2.10 WET SPRINKLER ALARM CHECK VALVE

A. Contractor shall provide, where required, a completely engineered horizontal wet alarm check valve, retarding chamber, and trim assembly. Viking #H-2, Star or Reliable.

2.11 UNDERGROUND WATER VALVE

A. Resilient seated gate, valve, non-rising stem, 2" square valve nut, ductile iron construction with epoxy coated surfaces, both interior and exterior, 250 psi, mechanical joint ends. Provide yard box and cover.

B. Manufacture: American Darling, Clow, Dresser, or U.S. Pipe.

2.12 VALVE BOXES

A. Cast iron valve boxes for shutoff valves buried in ground shall be complete with bellbottoms, extension piece, top and cover. Boxes shall be suitable for the types of valves with which they are used. All valve boxes shall have a concrete collar flush with grade.

B. Lids shall have the applicable letters embossed upon the top surface. Tagging shall match existing lids.

C. Manufacturer: Tyler, ITT Grinnell, or equal.

2.13 PRESSURE REDUCING VALVES

A. Sprinkler System: Rough bronze body with red enameled hand wheel with integral check valve of the pressure reducing type. Outlet pressure shall not exceed 165 psig at maximum system pressures. Pressure settings to be field adjustable.
1. Manufacturer: Zurn #Z-3004

B. Fire Service: 150 class pressure rating, cast iron body with brass main valve trim, control system cast bronze with stainless steel trim
1. Manufacturer: Cla-Val #90-21UL.

2.14 PRESSURE RELIEF VALVE

A. Provide 3/4" pressure relief valve on discharge side of Sprinkler system pressure reducing valve. Set to a maximum of 175 psi.
1. Manufacturer: Zurn #P1000A.

2.15 BACKFLOW PREVENTER

A. Provide listed backflow prevention device as required by local codes and ordinances. Backflow prevention devices installed in the vertical position shall be approved for that orientation.

B. Double check detector check valve assembly: Epoxy coated, ductile iron construction, 175 psig working pressure, complete with two spring loaded "Y" type check valves, "Y" strainer with hose bibb on suction side of assembly, two OS&Y gate valves, test cocks, bypass water meter and bypass doublecheck. Ames Model 3001SS, Febco #856-DCDA, Watts #709-DCDA-OSY, Wilkins #950DA or approved equal

C. Reduced pressure backflow preventor: Ductile iron construction, 150 psig working pressure, complete with two spring loaded "Y" type check valves, "Y" strainer with hose bibb on suction side of assembly, one differential relief valve, two OS&Y gate valves and test cocks. Unit shall be tapped on both sides to accommodate installation of test cocks. Febco #860 RPA, Wilkins #975DA, Watts #909-RPDA or approved equal.

D. Detector check valve assemblies: Ductile iron construction, 150 psig working pressure, complete with spring loaded check valve, two OS&Y gate valves and four test cocks. Febco #800 or approved equal.

2.16 INTEGRAL INSPECTORS ALARM TEST AND SYSTEM DRAIN

A. Combination system drain and visible orifice insert/sight glass for testing system alarm; with screwed or grooved inlet and outlet connections, Malleable iron hand wheel, EPDM valve seats, maximum working pressure 300 psi, 1/2" orifice insert, Bronze housing with 1/2" pressure relief valve, Watts Regulator Model FP 53L, 175 psi, UL listed and FM Approved. Victaulic TestMaster II style 720, or approved equal.

B. Water pressure gauge, range 0-300, in 5 psig increments, brass case - 3-1/2" diameter, 1/4" NPT male pipe connection, UL listed. Locate pressure gage on riser per code. Star Sprinkler, Ashcroft or approved equal.

C. Pressure gauge test valve, brass 1/4" screwed ends, 300 psig WOG. United or approved equal.

D. All relief, main, auxiliary and equipment drains shall be routed separately to floor drain or air gap fitting (by plumbing).

2.17 TAMPER SWITCHES

A. Switch shall be mounted so as not to interfere with normal operation of the valve and be adjusted to operate when handle of valve has traveled more than one-fifth the distance of its normal operating position. Electrical Contractor shall provide conduit from switch to fire alarm panel.

B. Housing shall be of aluminum, acid-treated, primed and finished in baked red enamel. Removal of housing shall cause switch to operate. Inside shall be single pole, double throw micro switch with connection for electrical conduit.

C. Install on all control valves.

D. Manufacturer: Potter-Electric, Notifier, Ellenco, or Simplex.

2.18 WATER FLOW ALARM - VANE TYPE

A. Indicator shall be for either vertical or horizontal installation. Indicator shall not be installed in a fitting that changes direction of water flow and shall have a sensitivity setting to signal any flow of water that equals or exceeds the discharge from one sprinkler head. Provide retarding device to prevent false alarms from line surges.

B. Whenever a water flow alarm is installed in the piping system, an approved floor control valve shall be provided upstream of the alarm indicator. In addition, a drain is required downstream of the alarm indicator.

C. Each water flow alarm shall be wired to a Fire System. All wiring and conduits as required will be provided under Division 26. An alarm will automatically activate the local fire alarm system.

D. Manufacturer: Potter-Electric, Ellenco, Notifier, or Simplex.

2.19 EXTERIOR ALARM

A. Electric bell, 10" diameter, U.L. listed, weather-proof back box housing, 120 VAC, 99 dB at 10 FT; Potter model PBA12010 or equal.

B. Electric Horn: Potter-Electric, Ellenco, Notifier, or Simplex weatherproof, 120 VAC.

2.20 EXTINGUISHERS

A. Fire extinguishers shall be U.L. listed, type 2A10B:C. Cabinet door and frame shall be steel, recessed with gray enamel prime coat. Refer to Architectural drawings for exact location and elevation of each cabinet.

2.21 DRY-PIPE VALVE SYSTEM

A. Contractor shall provide where indicated on drawings a completely engineered dry-pipe valve assembly in accordance with NFPA Pamphlet No. 13.

B. Space shall be provided for all valving required. Dry-pipe alarm valve(s) shall be of the differential type with all accessories including, but not limited to, the following:
   1. Alarm Valve, Trim, Pressure Switch with auxiliary contacts for fire alarm connection, Water gong, Air maintenance device, listed air compressor unit designed to fill system in a minimum of thirty minutes, Dry type valves supplying more than 300 sprinkler heads shall be provided with quick opening device (accelerator).

C. Manufacturer: Viking #E, Star or Reliable.

2.22 FIRE DEPARTMENT CONNECTIONS

A. Flush wall mounted unit or freestanding unit with individual clapper valves, plugs and chains, locations as indicated on drawings. Escutcheon plate to be lettered as follows; “AUTO SPRINKLER”, “DRY STANDPIPE” or “AUTO SPRINKLER AND STANDPIPE”. Unit shall be polished chrome or brass finish, mounted 36" above finished grade. Number of inlets required shall be in accordance with regulations of the Fire Marshal or local fire department.

2.23 FIRE DEPARTMENT HOSE VALVES

A. Fire Department Valves: 2-1/2" <<with 3” outlets>> brass construction female to male angle valve with cap and chain, rough chrome finish and mounted 48" above finished floor.

B. Pressure Reducing Fire Department Valves: 2-1/2" <<with 3” outlets>> tamper proof, automatic pressure reducing, all brass male to female angle, rated at 400 psig rough brass finish, mounted 48" above finished floor.

C. Manufacturer: Croker, Elkhart, Powhattan Brass, Potter-Roemer or Zurn.

2.24 ROOF MANIFOLD

A. 6" x 2-1/2" x 2-1/2" <<3” x 3”>> straight pattern cast brass roof manifold, Croker Model No. 294 or approved equal. <<6" x 2-1/2" x 2-1/2" <<3” x 3”>> 90 degree pattern cast brass roof manifold, Croker Model No. 296 or approved equal (DSP only)>>.

2.25 POST INDICATOR VALVE

A. Indicator post valve and indicator post. Clow # 2925 or approved equal.

2.26 FIRE PUMPS

A. Electric Fire Pump FP-1:
   1. The fire pump shall be designed for the capacity scheduled on the drawings. The pump shall be horizontal split case, double suction impeller type. Peerless or approved equal.

2. The pump unit shall meet all requirements of the National Fire Protection Association Pamphlet #20, and shall be UL listed. The following accessories shall be included with the pump unit:
   a. 5" x 6" Discharge Increaser.
   b. Liquid filled compound pressure and vacuum gauge for suction and liquid filled pressure gauge for discharge both with gauge valves.
   c. Automatic Air Release Valve.
   d. 3/4" Casing Relief Valve.
   e. 6” x 5" Eccentric Suction Reducer.
3. Driver shall be an electric motor of the ODP type, wound for 480 volts, 3 phase, 60 cycle current. Locked rotor current shall not exceed the values specified in NFPA Pamphlet #20. Bearing shall be anti-friction ball or roller type. The drive shall be vertical open drip-proof, ball bearing type, AC, induction, squirrel cage “P” face motor.
4. Fire Pump Controller: The motor control equipment shall be completely assembled, wired and tested at the factory and the assembly shall be specifically U.L. approved for fire pump purposes. The controller shall be marked “Electric Fire Pump Controller”. All equipment shall be enclosed in one or more approved drip-tight enclosures. The controller shall be a Hubbel, Asco, or equal, combined manual and automatic starting incorporating the following:
   a. Disconnect switch, externally operable, quick-break type.
   b. Motor starter: Reduced voltage solid state type capable of being energized automatically through the pressure switch or manually by means of an externally operable handle.
   c. Running period timer: Set to keep motor in operation, when started automatically, for a minimum period of one minute for each 10 HP motor rating, but not to exceed 7 minutes.
   d. Pilot Lamp: To indicate circuit breaker closed and power available.
   e. Alarm Relay: To energize an audible or visible alarm through an independent source to indicate circuit breaker open or power failure.
   f. Ammeter test link and voltmeter test studs.
   g. Manual Selection Station: A two-position station shall be provided on the enclosure marked “Automatic” and “Non-Automatic”.
   h. Means shall be provided on the controller to operate an alarm signal continuously while the pump is running.
   i. Provide relays and contacts for connection by life safety section for remote monitoring and remote starting, as shown on electrical drawings. Provide additional set of contacts for building automation system.
   j. Mercoid pressure switch.
   k. Voltage surge arrestor.
   l. Pressure switch piping and fittings shall be brass. Provide dielectric isolation between brass piping and steel hanger rings.
5. Tests: The pump shall be hydrostatically tested to twice the working pressure. The pump unit shall be given a complete performance test and characteristic curves prepared from the test results shall be furnished. All field tests shall be arranged with and witnessed by the Owner’s Representatives, Architect, Local Fire Department, and the Manufacturer.

B. Closed Loop Fire Pump Flow Test
   1. Fire pumps shall have a closed loop for testing, including a Gerand Fire Pump Test Meter with 6" Venturi Mode K-750-6 (743) rated for 500 psig (M-750-6 (743) rated for 175 PSI) or approved equal. Meter shall be wall mounted reading directly in gpm, meter range 450 to 1500 gpm. Provide mud leg and auxiliary drain in piping to meter.

C. Jockey Pump JP-1
   1. Pump shall be designed for the capacity scheduled on the drawings. Pump shall be turbine type with cast iron case, bronze impeller, steel shaft, and 480 V/3 pH/60 Hz, 3500 RPM motor. Peerless model J or approved equal.

2. Jockey Pump Control Panel: Jockey pump control equipment shall be completely assembled, wired, and tested at the factory. The controller shall be marked “Fire Jockey Pump Controller”. All equipment shall be enclosed in one or more approved drip-tight enclosures. Controller shall be a Hubble Industrial Controls Co. or approved equal of the combined manual and automatic type incorporating the following:
   a. Externally operable fusible disconnect switch.
   b. Across-the-line motor starter.
   c. Three position pilot switch “Manual-Off-Automatic”.
   d. Running period timer to keep motor running for a predetermined time after each automatic start and thus prevent too frequent starting and stopping of the motor.
   e. Pressure regulator with adjustable cut-in pressure points, which control the automatic operation of the motor.

D. Fire Pump Tests
1. Field acceptance tests shall be performed as required by NFPA Pamphlet #20. All field tests shall be arranged with and witnessed by the representatives of the Owner, Architect, Fire Department, and Manufacturer.

E. Sequence of Operation
1. Upon lowered system pressure the jockey pump shall start. Upon further lowering of system pressure, the electric driven pump shall automatically start. And further lowering of the system pressure, the diesel driven pump shall automatically start. All controls to accomplish this sequence of starting shall be provided under this contract. Controls shall be field adjustable.

F. Fire Pump Test Header
1. Provide flush mounted test heater, one valved outlet per each 250 GPM.
2. Manufacturer: Potter Roemer 586 # brass finish.

2.27 FIRE PUMP SEISMIC CALCULATIONS

A. Contractor to submit complete seismic restraint calculations for all submitted fire pumps, batteries, and fuel oil day tank. Calculations shall be signed by Registered Structural Engineer.

PART 3 - EXECUTION

3.1 GENERAL

A. This system to be installed by an experienced firm regularly engaged in the installation of automatic sprinkler system as specified by the requirements of the Specifications.

3.2 PERFORMANCE OF WORK

A. Examine areas and conditions under which materials are to be installed. Layout the system to suit the different types of construction and equipment as indicated on the drawings and in accordance with NFPA Pamphlet No. 13, 14, 20 and 24.

B. Work to start immediately after authorization has been given to proceed so that the overall progress of the construction is not delayed.

C. Coordinate with other trades as necessary to properly interface components of the sprinkler system.

D. Follow manufacturer's directions and recommendations in all cases.

E. The omission from the drawings or Specifications of any details of construction, installation, materials, or essential specialties shall not relieve the Contractor from furnishing the same in place for a complete system.

3.3 TEMPORARY FIRE PROTECTION

A. Provide all temporary valving, piping, Siamese connections and other components as directed by the fire agency office during all phases of construction.

3.4 INSTALLATION - GENERAL

A. Fire protection system shall be installed in accordance with the approved Drawings. The finished ceiling is not to be erected until all fire protection piping has been installed, tested, and inspected. Sprinkler heads located in the electrical equipment, elevator machine, or similar rooms shall be furnished with deflectors to prevent water spray on equipment.

B. Before connection to the overhead piping, all underground piping shall be flushed with water flowing at velocity and quantity required by the installation standards specified above in this Section of the Specifications.

C. The arrangement of all pipes shall conform to all architectural requirements and field conditions, shall be as straight and direct as possible, forming right angles or parallel lines with building walls and other pipes, and shall be neatly spaced. Offsets will be permitted only where required to permit the pipes to follow the walls. Standard fittings shall be used for offsets. All risers shall be erected plumb and true, shall be parallel with the walls and other pipes, and shall be neatly spaced. All work shall be coordinated with HVAC, Plumbing, Electrical and Structural work in order to avoid interference and unnecessary cutting of floors or walls. All underground or concealed work shall be inspected before the construction is closed up.

D. All sprinkler heads to be installed in ceilings throughout the scope of work building as listed in Part 2 sections. All areas without ceilings shall have rough brass upright or pendent heads as shown on drawings.

E. Sprinkler heads in all finished areas are to be installed on a true axis line in both directions, with maximum deviation from the axis line of 1/2 inch plus or minus and shall be plus or minus 1" within center of tile. At the completion of the installation, if any heads are found to exceed the above-mentioned tolerance, they shall be removed and reinstalled.

F. No pipes or other apparatus shall be installed so as to interfere in any way with full swing of doors.

G. The arrangement, positions, and connections of pipes, drains, valves, etc., shall be as required by NFPA Pamphlet #13 for all areas to be sprinklered. At all low points provide drains and provide drains or capped tees fittings at isolated low points in the piping system. However, the right is reserved by the Owner’s Representative to change the location of any item to accommodate conditions, which may arise during progress of the work, without additional compensation for such changes provided that no additional heads are required prior to the installation of the work.

H. Where required, piping shall be installed concealed in building construction, or though steel beams, to obtain adequate head room.

I. All pipe throughout the job shall be reamed smooth before being installed. Pipe shall not be split, bent, flattened, or otherwise injured either before or during installation.

J. Provide protective pans under pipes passing over high voltage electrical bus duct or switchgear equipment. The pan shall be constructed of 12 gauge black iron with a 6 inch lip, the corners being welded to make the pans watertight. Each pan shall be given three coats of Rust-Oleum paint and shall be supported by pipe hangers. The pan shall drain clear of the bus duct or switchgear.

K. All pipe interiors shall be thoroughly cleaned of foreign matter before installation, and shall be kept clean during installation by plugging or other approved means. Piping shall be covered with visqueen during storage. Piping that shows signs of rusting will be removed from job site and replaced.

L. Field Connections: Any modifications to system required by field conditions, physical equipment changes or compliance with code regulations shall be made promptly without cost to Owner.

M. Interference: No piping or sprinkler devices shall interfere with the operations of any door, window, or mechanical and/or electrical systems. No part of this system shall visibly installed in the physical parameter of any window.

N. Threaded Pipe: Threads shall be clean cut, standard and tapered. Threads shall be made up using flaked graphite and lubricating oil, piping compound or Teflon tape applied to the male threads only.

O. Grooved Pipe: Installation shall be as prescribed in the Victaulic Piping Manual only. Holes in the piping are to be made in the fabrication shop, not at the job site. Contractor shall provide at the project site a sample of each type of coupling (threaded, standard grooved coupling and mechanical type), showing complete assembly with pipe connections. Couplings will not be installed until samples are approved by the Owner's Representative. Owner's Representative approval does not eliminate the Contractor's final approval by the fire agency's office.

P. Keep all pipe and other openings closed to prevent entry of foreign matter. Cover all equipment and apparatus to protect against dirt, water, chemical or mechanical damage, before and during construction period. Restore to original condition all apparatus and equipment damaged prior to final acceptance, including restoration of damaged shop coats of paint.

Q. Location of sprinkler piping is critical.
1. Where ceiling space is at a minimum under beams location of ductwork takes precedence, coordinate accordingly.
2. Include in base bid, multiple coordination meetings, as required with Owner's Representative for coordination of sprinkler pipe routing, at no additional cost to the Owner.
3. Coordinate beam and shear wall penetrations with Structural Engineer. Obtain written approval for all beam penetrations from Structural Engineer.

R. Tracer wire shall be wrapped and taped to non-metallic underground piping at maximum 20 foot intervals.

3.5 EXCAVATION AND BACKFILL

A. Trench and excavation work shall be done in a neat workmanlike manner, of the depth required by the authorities and/or agencies having jurisdiction. Pipe crown shall not be less than 30 inches below the finished ground surface. After the pipe has been properly tested and inspected, trench shall be backfilled with sand, or an approved sandy material, to a depth of 6 inches above the pipe. Backfill material shall be consolidated by tamping or by saturating with water and vibrating. Subsequent backfill shall consist of the original excavated material, free of organic matter, placed in 6 inch layers and compacted layer by layer by means of power driven vibrators.

B. Replace to original condition all turf, plants, concrete, asphalt, or other improvements disturbed by trenching. In graded, unpaved areas, backfill trenches with crown 8 inches above the surrounding surface.

3.6 SLEEVES AND FLASHINGS

A. Wherever pipes are exposed and pass through walls, floors, partitions or ceilings, they shall be fitted with chromium plated steel escutcheons held in place with setscrews. Care shall be taken to protect the escutcheons during the course of construction.

B. Penetrations through fire rated walls and floors shall be sealed with listed mastic of similar fire rating.

3.7 HANGERS, INSERTS, SUPPORTS, AND SWAY BRACING

A. Hangers and supports shall be installed per NFPA #13 sections on Hangers and Protection of Piping Against Damage Where Subject to Earthquake. Provide restraint from movement at end sprinkler on branch line per NFPA 13.

B. Bending of threaded hanger rod is not allowed. All powder driven anchor pins in concrete are not allowed.

3.8 SAFETY TESTING & VERIFICATION

A. Flush, test, and inspect sprinkler piping systems according to NFPA 13 Chapter "System Acceptance."

B. Provide NFPA 13 Contractor's Material & Test Certificate Form 85A for above ground piping and Form 85B for underground piping.

C. Provide manpower to test the function and performance of all Life Safety System components and devices per floor and per zone basis in accordance with the local requirements.

3.9 FIRE PUMP COMMISSIONING

A. Starting Procedures: Follow manufacturer’s written procedures. If no procedures are prescribed by manufacturer, proceed as follows:
   1. Verify that specialty valve, trim, fittings, control and accessories have been installed correctly and operate correctly.
   2. Verify that fire pumps and accessories have been installed correctly and operate correctly.
   3. Verify that jockey pumps and accessories have been installed correctly and operate correctly.
   4. Verify that specified tests of piping are complete.
   5. Check that damaged sprinklers and sprinklers with paint or coating not specified have been replaced with new, correct type of sprinklers.
   6. Check that sprinklers are correct type, have correct finish and temperature ratings, and have guards where required for applications.
   7. Check that potable water supplies have correct type of backflow preventer.
   8. Check that fire department connections have thread compatible with local fire department equipment and have correct pressure rating.
   9. Fill wet-pipe sprinkler systems with water.
   10. Energize circuits to electrical equipment and devices.
   11. Start and run jockey pumps.
   12. Adjust operating controls and pressure settings.

B. Perform fire pump field acceptance test as indicated elsewhere in this section. Operate system as required.

3.10 IDENTIFICATION

A. In addition to the requirements of Section 210500, provide pipe markers every 20 feet, once in every room, and at each building level traversed, minimum. zone numbers on risers.

B. Provide hydraulic design data nameplates on the riser of each sprinkler system in accordance with NFPA 13

C. Equipment such as valves, drains, etc., shall be provided with signs that identify type of equipment and service. The tag shall be securely fastened to the handle or spindle of the valve by a brass chain. Furnish four schedules of valves so tagged. There shall also be furnished four diagrammatic charts showing schematically the complete sprinkler system with major control valves and numbers thereof. One set of Schedules and charts shall be mounted in glazed frames located where directed.

3.11 AS-BUILT RECORD DRAWINGS AND CERTIFICATION

A. As-built Record Drawings are to be kept up-to-date and the Master Copy kept at the job site. Prior to final acceptance of work being approved, these drawings are to be turned over to the Owner's Representative for approval.

B. Written certification from the insuring agents, and authorities having jurisdiction that the tests were satisfactory.

C. After installation is complete and tests satisfactorily approved, deliver test certificates and approval by the local Fire Authorities and the FMA to the architect. Final acceptance of sprinkler/standpipe system by Owner's Representative shall be contingent upon receipt of certificate and approval from authorities having jurisdiction and for the delivery of final As-Built Drawings.

END OF SECTION 211000

SECTION 220500

BASIC PLUMBING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE OF THIS SECTION

A. Work to be furnished and installed under this Section shall include, but not necessarily be limited to, the following:
1. Compliance with all codes and standards applicable to this jurisdiction.
2. Shop Drawings for Equipment
3. Coordination Documents
4. Record drawings
5. Start-up and commissioning service
6. Instruction, Training, and Operations & Maintenance Manuals
7. Work associated with delivery, storage, and handling of products
8. Work associated with provision of temporary facilities
9. Preparation of posted operating instructions
10. Meeting project safety and indemnity requirements
11. Proper cleaning and closing
12. Supplying proper Warranty information
13. Supply specified Guarantee documentation
14. Design and provision of supports and anchors
15. Design and provision of seismic restraints
16. Design and provision of vibration isolation
17. Through-penetration firestop assemblies
18. Pipe portals
19. Pipe stands
20. Equipment supports
21. Access panels and doors
22. Roof flashings
23. Water hammer arrestors
24. Drains
25. Trap primers
26. Miscellaneous fixtures
27. Identification mmarkers, equipment labels, pipe labels, valve tags, warning signs.
28. Coordination of eelectrical requirements for equipment provided

1.2 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to include all material and labor to install complete plumbing systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and shall coordinate the work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the fixtures, equipment, and pipe lines and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing building and/or site systems, existing utilities and services have been indicated on the drawings to the extent possible based on available record drawings. The Contractor shall thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. Refer to Basis of Design on drawings. Systems as specified under this section shall include but not necessarily be limited to the following:
   1. Connection to utilities at five (5) feet from the building. Coordinate with the Civil Engineering Plans and/or Division 02 work.
   2. Connection of all waste, vent, and water piping to all plumbing fixtures, drinking fountains, sinks, water coolers, drains and mechanical equipment.
   3. Connect cold and/or hot water to hose bibbs and wall hydrants. Provide individual shut-off valves at each location.
   4. Provide traps on all floor drains with trap primer where specified. Pipe to trap shall be 1/2" minimum.
   5. Provide floor drainage in restrooms, mechanical rooms and equipment rooms.
   6. Provide connections for all area drains, catch basins, downspouts, roof drains and overflow drains to storm sewer system.

1.3 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01. Submit manufacturer's data, installation instructions, and maintenance and operating instructions for all components of this section including, but not limited to, the following:
   1. Supports and anchors
   2. Access panels and doors
   3. Identification markers, labels and tags
   4. Electrical equipment
   5. Pipe portals
   6. Plumbing specialties
   7. Trap primers
   8. Cleanouts
   9. Drains
   10. Roof flashing
   11. Wall hydrants and hose bibbs
   12. Backwater valves

1.4 DESCRIPTION OF BID DOCUMENTS

A. Specifications:
   1. Specifications, in general, describe quality and character of materials and equipment.
   2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:
   1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and details of installation.
   2. Before proceeding with work check and verify all dimensions.
   3. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
   4. Make adjustments that may be necessary or requested, in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
   5. Verify exact location and elevation of existing piping, ductwork, conduits and structure and coordinate to accommodate installation of new work as indicated on the drawings.

6. If any part of Specifications or Drawings appears unclear or contradictory, apply to the Owner's Representative for interpretation and decision as early as possible, including during bidding period.

1.5 DEFINITIONS

A. "Above Grade": Not buried in the ground and not embedded in concrete slab on ground.

B. "Actuating" or "Control" Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

C. "Below Grade": Buried in the ground or embedded in concrete slab on ground.

D. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

E. "Connect": Complete hook-up of item with required service.

F. "Exposed": Not installed underground or "concealed."

G. "Furnish": To supply equipment and products as specified.

H. "Indicated," "Shown" or " "Noted": As indicated, shown or noted on Drawings or Specifications.

I. "Install": To erect, mount and connect complete with related accessories.

J. "Lead Free": Materials containing not more than 0.2 percent lead when used with respect to solder and flux and not more than a weighted average of 0.25 percent when used with respect to the wetted surfaces of pipes and pipe fittings, plumbing fittings, and fixtures, providing a specified definition and formula for determining "weighted average".

K. "Motor Controllers": Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

L. "Must": A desire to complete the specified task. Allows some flexibility in application as opposed to "Shall."

M. "NRTL": Nationally Recognized Testing Laboratory, including UL and/or ETL.

N. "Piping": Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

O. "Provide": To supply, install and connect as specified for a complete, safe and operationally ready system.

P. "Reviewed," "Satisfactory" or "Directed": As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner's Representative.

Q. "Rough-In": Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

R. "Shall": An exhortation or command to complete the specified task.

S. "Similar" or "Equal": Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

T. "Supply": To purchase, procure, acquire and deliver complete with related accessories.

U. “Typical” or “Typ”: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

V. "Will": A desire to complete the specified task. Allows some flexibility in application as opposed to "Shall."

W. "Wiring": Raceway, fittings, wire, boxes and related items.

X. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.6 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 22 Plumbing sections included herein.

B. Division 01: General Requirements
1. Including commissioning requirements.

C. Division 02: Existing Conditions
1. Coordination of excavation of trenches and the installation of mechanical systems and piping on site.

D. Division 03: Concrete.
1. All concrete work required for plumbing work shall be coordinated by Division 22 with Division 03 including:
a. Concrete curbs and housekeeping pads for the mechanical equipment.
b. Thrust blocks, pads, and boxes for mechanical equipment.
c. Coordination of floor drain and floor sink installations in sloped floors.

E. Division 07: Thermal and Moisture Protection.
1. Flashing and sheet metal
2. Sealants and caulking
3. Firestopping

F. Division 09: Finishes:
1. Division 22 installers shall perform all painting, except where specifically stated otherwise in Division 09.
2. Painting of all exposed steel, piping, insulation, equipment, and materials.

G. Division 26: Electrical is related to work of:
1. Power connections to all plumbing equipment
2. Life safety provisions

1.7 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 22 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

E. Provide in accordance with rules and regulations of the following:
   1. Building Codes enforced by the Authority Having Jurisdiction in Washington:
      a. 2015 International Building Code (IBC) with State Amendments
      b. 2015 International Mechanical Code (IMC) with State Amendments
      c. 2015 Uniform Plumbing Code (UPC) with State Amendments
      d. 2015 International Fire Code (IFC) with State Amendment
      e. 2017 National Electrical Code (NEC)
      f. 2015 Washington State Energy Code, (WAC 51-11, WSEC)
   2. Local, city, county and state codes and amendments
   3. Local and State Fire Prevention Districts
   4. Local Health Department
   5. State Administrative Codes

F. All accessible plumbing work shall comply with the Americans with Disabilities Act (ADA) and local amendments. Compliance requirements applicable to plumbing work includes, but is not limited to, the following ADA requirements:
   1. Section 609: No plumbing fixtures or valves may impede on grab bar clearances. Grab bars are installed in a horizontal position between 33” and 36” above the finish floor to the top of the grab bar. The clear space between the wall and the grab bar shall be 1-1/2” minimum with no obstructions created by valves, fittings or controls. The space between the grab bar and projecting objects above shall be 12” minimum. The space between the grab bar and projecting objects below shall be 1-1/2” minimum.
   2. Section 604.4: The seat height of a water closet above the finish floor shall be 17” minimum and 19” maximum measured to the top of the seat. Seats shall not be sprung to return to a lifted position. A water closet in a toilet room for a single occupant accessed only through a private office and not for common use or public use shall not be required to comply. In residential dwelling units the height of water closets shall be permitted to be 15” minimum and 19” maximum above the finish floor measured to the top of the seat.
   3. Section 605.2: Urinal shall be a stall-type or wall-hung type with the rim 17” maximum above the finish floor or ground. Urinals shall be 13-1/2” deep minimum.
   4. Section 608.6: A shower spray unit with a hose 59” minimum that can be used both as a fixed-position shower head and as hand-held shower. The shower spray unit shall have an on/off control with a non-positive shut-off. The shower unit shall not obstruct grad bar clearances. Shower spray units shall deliver water that does not exceed 120ºF maximum.
   5. Section 608.7: Thresholds in roll-in type shower compartments shall be 1/2” high maximum.
   6. Section 604.9: Water closets in buildings serving children ages 3 through 12 shall comply with reduced dimensions.
   7. Section 606.3: Lavatories and sinks shall be installed with the front of the higher of the rim or counter surface 34” maximum above the finish floor.
   8. Section 606.4: Hand-operated metering faucets shall remain open for 10 seconds minimum.
   9. Section 606.5: Water supply and drain pipes under lavatories and sinks shall be insulated or otherwise configures to protect against contact. There shall be no sharp or abrasive surfaces under lavatories and sinks.
   10. Section 309: Operable parts shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate operable parts shall be 5 pounds maximum.

G. Provide in accordance with appropriate referenced standards of the following:
   1. NFPA - National Fire Protection Association
   2. CSA - Canadian Standards Association
   3. ADC - Air Diffuser Council
   4. ANSI - American National Standards Institute
   5. ASHRAE - American Society of Heating, Refrigerating & Air Conditioning Engineers
   6. ASME - American Society of Mechanical Engineers
   7. ASTM - American Society for Testing Materials

8. AWS - American Welding Society
9. MSS - Manufacturer's Standardization Society
10. NEMA - National Electrical Manufacturer's Association
11. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
12. UL - Underwriter's Laboratories
13. ADA - Americans with Disabilities Act
14. ETL - Electrical Testing Laboratories
15. ASSE - American Society of Sanitary Engineers
16. PDI - Plumbing and Drainage Institute
17. IAPMO - International Association of Plumbing and Mechanical Officials
18. CISPI - Cast Iron Soil Pipe Institute

1.8 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be affixed to each piece of equipment and resistant to ambient conditions.

B. All work shall include the following:
1. Manufactured items and equipment shall be a current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

C. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

1.9 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permits, licenses, fees and inspections.

D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access.

E. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to Equipment Specifications in Divisions 02 through 48 for rough-in requirements.

F. Coordinate plumbing equipment and materials installation with other building components.

G. Verify all dimensions by field measurements.

H. Arrange for chases, slots, and openings in other building components to allow for plumbing installations.

I. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

J. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted.

K. Where mounting heights are not detailed or dimensioned, install plumbing services and overhead equipment to provide the maximum headroom possible.

L. Install plumbing equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

M. Coordinate the installation of plumbing materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, and other installations.

N. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

O. Coordinate with Owner's Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

P. All materials (such as insulation, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

Q. Coordinate installation of floor drains and floor sinks with work of other trades. Finished floors shall slopes to floor drains as shown on architectural drawings. Floor sinks will typically be installed flush with surrounding floor. Review plans and design intent for floor sinks that may require elevated rims.

R. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

S. Pipes, pipe fittings, plumbing fittings and fixtures that come into contact with the wetted surface of a public water system or any plumbing in a facility providing water for human consumption shall be "Lead Free".

1.10 MINOR DEVIATIONS

A. The Drawings are diagrammatic and show the general arrangements of all plumbing work and requirements to be performed. It is not intended to show or indicate all offsets, fittings, and accessories which will be required as a part of the work of this Section.

B. The Contractor shall review the structural and architectural conditions affecting the work. The contractor's scope of work shall include
   1. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications
   2. Minor deviations from the plumbing plans required by architectural and structural coordination.

C. The Contractor shall study the operational requirements of each system, and shall arrange the work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems within the physical space available for use by this

section. This requirement extends to the Contractor's coordination of this section's work with the "Electrical Work." Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

D. Minor deviations in order to avoid conflict shall be permitted where the design intent is not altered.

E. Advise the Owner's Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

1.11 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:
1. The proposed substitution does not affect dimensions shown on drawings.
2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts are available locally and readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to the proposed substitution.

1.12 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Provide submittals for all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner's Representative for review and approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Submittals and Shop Drawings:
1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner's Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
3. Paper submittals will only be acceptable if specifically required by Division 01.
4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.13 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.
   1. The shop drawings shall serve to record the coordination of the installation and location of all piping, fixtures, HVAC equipment, ductwork, grilles, diffusers, fire sprinklers, lights, audio/video systems, electrical services and all system appurtenances.
   2. The Drawings shall include all mechanical rooms and floor plans.
   3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner's Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner's Representative.
   4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:
   1. Two dimensional AutoCAD / Revit based documents:
      a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
      b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
      c. Plumbing drawings shall indicate locations of all fixtures and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
      d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
      e. Drawings shall incorporate all addenda items and change orders.
      f. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner's Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

1.14 REQUESTS FOR INFORMATION (RFIS)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).
   1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
   2. RFIs shall address single questions and related issues only.
   3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner’s Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
   1. Project name.
   2. Project number.
   3. Date.
   4. Name of Contractor.
   5. Name of Architect and Construction Manager.
   6. RFI number, numbered sequentially and unique.
   7. RFI subject.
   8. Specification Section number and title and related paragraphs, as appropriate.
   9. Drawing number and detail references, as appropriate.
   10. Field dimensions and conditions, as appropriate.
   11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
   12. Contractor's signature.
   13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
      a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer’s Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.
   1. The following Contractor-generated RFIs will be returned without action:
      a. Incomplete RFIs or inaccurately prepared RFIs.
      b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
      c. RFIs addressing multiple unrelated issues.
      d. Requests for approval of submittals.
      e. Requests for approval of substitutions.
      f. Requests for approval of Contractor's means and methods.
      g. Requests for information already indicated in the Contract Documents.
      h. Requests for adjustments in the Contract Time or the Contract Sum.
      i. Requests for interpretation of Engineer's actions on submittals.
   2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.15 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked “Record Set” at the job site at all times, and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping, size and location both exterior and interior; including locations control devices, and equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance (i.e. – valves, traps, strainers, expansion compensators, tanks, etc.).

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. At the completion of the construction transfer all “Record Set” notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

E. Refer also to Division 01 for full scope of requirements.

1.16 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. O&M Manuals: Contractor shall submit to the Owner’s Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section.

B. The Contractor shall be responsible for proper instruction of Owner's personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 22, to be no less than two (2) hours for each type of equipment.

C. Refer to Division 01 for additional requirements.

1.17 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with manufacturer’s names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment that is damaged or showing signs of rust shall be removed from site and replaced with new.

1.18 START-UP SERVICE

A. Prior to start-up, assure that systems are ready for start-up and commissioning, including checking the following: proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of controls, pumps, water heaters, and other major pieces of equipment. Certify in writing, compliance with this paragraph, stating names of personnel involved and the date work was performed.

C. Refer to other Division 01 and Division 22 sections for additional requirements.

1.19 TEMPORARY FACILITIES

A. Refer to Division 01 for the requirements of temporary water and sewer for construction and safety. Provide temporary water, and sewer, etc. services as necessary during the construction period and as required to maintain operation of existing systems.

1.20 POSTED OPERATING INSTRUCTIONS

A. Print or engrave operating instructions and frame under glass or UV resistant plastic. Post instructions as directed by Owner's Representative. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.21 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work for the duration of the project.

B. No act, service, Drawing, review, or Construction Review by the Owner, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.22 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner's Representative.

1.23 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, defined as starting from the date of Certificate of Occupancy, and shall include all parts, material, labor and travel.

D. Refer to individual Specification sections for additional extended warranty requirements.

E. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

F. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.24 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after the Certificate of Occupancy, ordinary wear and tear excepted.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

2.2 GENERAL

A. All materials and equipment under this Division of the Specifications shall be new, of best grade and as listed in printed catalogs of the manufacturer.

B. All manufactured materials shall be delivered and stored in their original containers. Equipment shall be clearly marked or stamped with the manufacturer's name and rating.

C. For secure facilities, schools and public safety buildings exposed equipment and access shall be Vandal Proofed. One type of vandal proof screw is to be used throughout this facility. Coordinate with General Contractor for type.

D. The following products to be included as part of this work but specified under Section 220500 Basic Plumbing Materials and Methods and Section 221123 Plumbing Piping, Valves and Specialties:
1. Piping.
2. Valves.
3. Hangers and supports.
4. Escutcheon plates, flashings, and sleeves.
5. Identification markers and signs.
6. Anchors and alignment guides to comply with seismic requirements as indicated on structural plans.
7. Excavation and backfill.
8. Pressure and temperature gauges.
9. Access Panels.

E. Plumbing Fixtures: Refer to Section 224000.

F. Plumbing Equipment: Refer to Section 223000.

G. Products made of, or containing, lead, asbestos, mercury, or other known toxic or hazardous materials are not acceptable for installation under this Section. Any such products installed as part of the work of this Section shall be removed and replaced and all costs for removal and replacement shall be borne solely by the Contractor(s).

2.3 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:
1. UL: Provide products which are UL listed.
2. FM: Provide products which are FM approved.
3. ASCE 7-05: “American Society of Civil Engineers.”
4. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
5. SMACNA: "Seismic Restraint Manual: Guidelines for Mechanical Systems."
6. NFPA: Pamphlet number 13 and 14 for fire protection systems.
7. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.
8. Manufacturer: Hilti Inc, B-Line/Tolco, Anvil International, Erico, Kin-Line, Simpson, or Superstrut.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS types listed.
1. Adjustable Steel Clevis Hangers: MSS Type 1.
2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
3. U-Bolts: MSS Type 24.
4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
   a. Plate: Unguided type.
   b. Plate: Guided type.
   c. Plate: Hold-down clamp type.
5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
8. Single Pipe Roller with Malleable Sockets: MSS Type 41.
9. Adjustable Roller Hangers: MSS Type 43.
10. Pipe Roll Stands: MSS Type 44.
11. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp or equal.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.
1. Steel Turnbuckles: MSS Type 13.
2. Steel Clevises: MSS Type 14.
3. Swivel Turnbuckles: MSS Type 15.
4. Malleable Iron Eye Sockets: MSS Type 16.
5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated, provide factory-fabricated building attachments of one of the following types listed.
   1. Concrete Inserts: HCI-MD (for metal deck) or HCI-WF (for wood forms) cast-in anchors by Hilti Inc. or MSS Type 18 or Blue Banger Hanger by Simpson
   2. Steel Brackets: One of the following for indicated loading:
      a. Light Duty: MSS Type 31.
      b. Medium Duty: MSS Type 32.
      c. Heavy Duty: MSS Type 33.
   3. Horizontal Travelers: MSS Type 58.
   4. Concrete Screw Anchors: KWIK HUS EZ-I by Hilti Inc., Titen HD by Simpson or approved equal.
   5. Torque-Controlled Expansion Anchor: KWIK BOLT-TZ by Hilti Inc., Strong-Bolt 2 by Simpson Strong-Tie Co. Inc or approved equal.

G. Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
   1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
   2. Insulation Protection Shields: MSS Type 40, 18” minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
   3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert. Alternately Polyisocyanurate Urethane with a minimum flexural strength of 60psi, fully encased in 360 PVC (1.524 mm thick) SNAPPITZ. Provide assembly of same thickness as adjoining insulation.
   4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain tubing and join insulation at clevis hangers and strut-mounted clamps. Klo-Shure Insulation Coupling or equal.

H. Miscellaneous Materials:
   1. Metal Framing: Provide products complying with NEMA STD ML1.
   2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
   3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand by volume, with minimum amount of water required for placement and hydration.
   4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.
   5. Pipe Brackets: "HoldRite" copper plated brackets. Insulate brackets attached to metal studs with felt.

2.4 SEISMIC RESTRAINT/VIBRATION ISOLATION REQUIREMENTS

A. Equipment, piping, and all system appurtenances (including weight of normal operating contents) shall be adequately restrained to resist seismic forces. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest code editions with State Amendments, applicable local codes, and applicable Importance Factors and Soil Factors. Refer to Section 220548 Vibration Isolation for Plumbing Equipment or Section 220549 Seismic Restraint for Plumbing Piping and Equipment, as applicable.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-penetration firestop assemblies and caulking systems as required to maintain the fire/smoke integrity of the penetrated surface and install per manufacturer's installation instructions. Refer to drawings for additional requirements.

B. Manufacturers: 3M, Hilti, ProSet or equal.

2.6 PIPE PORTALS

A. Where pipe portals are not provided by other sections of Specification, provide prefabricated insulated pipe portals as required for piping penetrating through the roof where shown on plans. Field built pipe portals are acceptable alternatives - provide detail of construction for review.

B. Standard pipe portals, unless otherwise noted, shall be constructed as follows:
   1. Curb shall be constructed of heavy gauge galvanized steel with continuous welds on shell seams.
   2. Insulation to be 1-1/2" thick, 3 lb density rigid fiberglass.
   3. Curb to have a raised 3" (minimum), 45° cant.
   4. Curb to have 1-1/2" x 1-1/2" wood nailer (minimum).
   5. Curb height to be 8" (minimum) above roof deck.
   6. Cant shall be raised to match roof insulation thickness.
   7. Cover or flashing to be constructed of galvanized steel or other suitable material to provide sturdy weather tight closure. Provide collars and rubber nipples with draw bands of sizes required by piping. Size curb, cover and nipples per manufacturer's recommendations.
   8. Manufacturer: Roof Products Systems or Pate.

2.7 PIPE STANDS

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

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

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

D. High-Type, Single-Pipe Stand:
   1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   2. Base: Plastic or stainless steel.
   3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

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

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

G. Manufacturer: Pate, Roof Products Systems, Portable Pipe Hangers, Roof Top Blox, or Erico Caddy Pyramid.

2.8 EQUIPMENT/PIPING RAILS

A. Where equipment/pipe rails are not provided by other sections of Specification, provide prefabricated reinforced equipment rails as required for support of equipment and piping. Field built curbs are acceptable alternatives - provide detail of construction for review.

B. Standard equipment rail, unless otherwise noted, shall be constructed as follows:
1. Construct of heavy gauge galvanized steel with continuous welds on shell seams.
2. Provide internal reinforcing supports welded as required to meet application requirements.
3. Equipment rails to have raised 3” (minimum), 45° cant.
4. Equipment rails to have 1 1/2" x 1 1/2" wood nailer (minimum) and counterflashing.
5. Equipment rail height to be 6” (minimum) above roof deck.
6. Cant shall be raised to match roof insulation thickness.

C. Equipment rails to be constructed to meet equipment size and weight requirements. Provide tapered rails to match roof pitch where required.

D. Manufacturer: Pate, Vent Products, Thy Curb or Roof Products Systems.

2.9 ACCESS PANELS AND ACCESS DOORS

A. Provide all access doors and panels to serve equipment under this work, including those which must be installed, in finished architectural surfaces. Frame of 16-gauge steel, door of 20 gauge steel. 1” flange width, continuous piano hinge, key operated, prime coated. Refer to Architectural Specifications for the required product Specification for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels is not shown on Plans. Access doors shall be of a size to permit removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each trap primer or concealed valve. Use no panel smaller than 12” x 12” for simple manual access, or smaller than 24" x 24" where personnel must pass through. Provide cylinder lock for access door serving mixing or critical valves in public areas.

B. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to serve equipment under this work and in the proper sequence to keep in tune with construction and with prior approval of the Owner’s Representative. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.

C. Acceptable Manufacturers: Milcor, Karp, Nystrom, or Elmdor/Stoneman.

D. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner’s Representative.

2.10 PIPING

A. Refer to Section 221000 Plumbing Piping, Valves and Specialties

2.11 VALVES

A. Refer to Section 221000 Plumbing Piping, Valves and Specialties.

2.12 PLUMBING EQUIPMENT

A. Refer to Section 223000 Plumbing Equipment.

2.13 PLUMBING FIXTURES

A. Refer to Section 224000 Plumbing Fixtures.

2.14 CLEANOUTS

A. Acceptable Manufacturers: J. R. Smith, Zurn, Wade, Sioux Chief and Josam.

B. Cleanout Plugs: Bronze, taper thread countersunk head.

C. Floor Cleanouts: Service weight cast-iron body and frame, flange with flashing clamp, adjustable cast-iron collar, caulk inside, Ty-seal or No-hub joints, neoprene plug gasket seal.
1. Carpeted Areas: Zurn ZN-1400-KC-VP-BP-CM or J. R. Smith 4028 C - F- C - Y - U
2. Tiled Areas: Zurn ZN-1400-X-KC-VP-BP or J.R. Smith 4148 - F - C - U
3. Unfinished Areas: Zurn ZN-1400-HD-KC-VP-BP or J.R. Smith 4108 C - F - C - U
4. Yard Areas: Zurn Z 1474-IN-VP or J.R. Smith 4258 - C - U

D. Cleanout Tee: Cast iron cleanout tee with countersunk brass plug, neoprene plug gasket seal and smooth stainless steel cover.
1. Manufacturer: Zurn Z-1446-BP or J. R. Smith 4532 S (Y)

2.15 ROOF FLASHING

A. Flashing: Unless indicated otherwise on the drawings flashings for pipes through the roof shall be galvanized sheet metal, 24 gauge minimum with seams and joints lapped and soldered watertight. Coordinate with Architectural Sections for flashings and roofing.

B. Vent Pipes: Provide caulk type for all vent pipes through roof or preformed vinyl/galvanized steel assembly.

2.16 WATER HAMMER ARRESTORS

A. Provide a water hammer arrestor before each quick closing valve, including but not limited to, flush valves, solenoid valves, electronic trap primers, pre-rinse faucets, dishwashers and banks of fixtures.

B. Piston or Bellows Type: Hard drawn copper construction or stainless steel, mirror finished internal surfaces; machine finished brass piston or stainless steel bellows, lead free, air pre-charged, 150 psi rated, tested and certified per PDI WH-201 and ASSE/ANSI 1010-2004.

C. Water hammer arrestors shall be sized based on the PDI WH-201 Standard method

D. Manufacturers: Watts #LF15 Series, Precision Plumbing Products #SC Series, Sioux Chief #650 Series, Mifab #WHB Series, JR Smith #5000 Series, or equal.

2.17 TRAP SEAL PRIMER

A. Single Fixture Trap Seal Primer Device:
1. Device shall conform to ASSE Standard 1018. Provide ball valve upstream of trap primer to allow for future maintenance and replacement.
2. Pressure Operating Range: 20-80 psi.
3. Pressure Activation: Minimum 3 psi differential and mounted with ten (10) feet of fixture source of pressure drop. Or, minimum 10 psi differential and mounted within three (3) feet of fixture source of pressure drop. Maximum pipe distance is 20 feet to floor drain.
4. Bronze body with removable filter screens. Chrome plated or rough bronze.
5. Inlet and outlet connections may be threaded, unions or soldered.
6. Manufacturer: Mifab #M-500 Series (3 psi activation), PPP #PO-500 (10 psi activation), Sioux Chief #695-01 (10 psi activation), or equal.

B. Multiple Fixture Trap Seal Primer Device:
   1. Device shall conform to ASSE Standard 1018. Provide ball valve upstream of trap primer to allow for future maintenance and replacement.
   2. Manifold or distribution unit to serve 2 to 10 floor drains.
   3. Pressure Operating Range: 20-80 psi.
   4. Pressure Activation: Minimum 3 psi differential and mounted with ten (10) feet of fixture source of pressure drop. Or, minimum 10 psi differential and mounted within three (3) feet of fixture source of pressure drop. Maximum pipe distance is 20 feet to floor drain.
   5. Bronze body with removable filter screens. Chrome plated or rough bronze.
   6. Inlet and outlet connections may be threaded, unions or soldered.
   7. Manufacturer: Mifab #M-500 Series (3 psi activation), PPP #PO-500 (10 psi activation), Sioux Chief #695-01 (10 psi activation), or equal.

C. Electronic Trap Seal Primer Device:
   1. Device shall conform to ASSE Standard 1044. Provide ball valve upstream of trap primer to allow for future maintenance and replacement.
   2. Manifold or distribution unit to serve 1 to 10 floor drains.
   3. Recessed steel cabinet with stainless steel cover or galvanized steel painted to match wall.
   4. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120 volt AC power. Coordinate power requirements with electrical design. Listed and labeled as defined in NFPA 70.
   5. Vacuum breaker compliant with ASSE 1001.
   6. Water hammer arrestor shall be integral or externally mounted upstream.
   7. Pressure Operating Range: 20-80 psi.
   8. Lead free construction.
   9. Inlet and outlet connections may be threaded or soldered.
   10. Manufacturer: Mifab #MI-100 Series, PPP #MP-500, Sioux Chief #695-E Series, or equal.

2.18 DRAINS

A. Provide drains of type and size as indicated in plumbing schedule on drawings, including features, as specified herein.
   1. Manufacturers: J.R. Smith, Zurn, Wade, Sioux Chief, Josam and Watts.

2.19 ANTI-CONTAMINATION WALL HYDRANTS AND HOSE BIBBS

A. Provide fixtures of type and size as indicated in plumbing schedule on drawings, including features, as specified herein.

2.20 BACKWATER VALVE (FOUNDATION DRAINAGE)

A. Drain Tile Sump: Enamel coated body with extension frame and solid cover. Zurn # Z-753 or J.R. Smith #7098.

B. Backwater Valve. Enamel coated body and cover with removable wheel handle, bronze gates and flapper valve and cast iron extension. Provide 30" diameter fiberglass or cast iron basin with access top, minimum. Zurn #Z-1088 or J.R. Smith series 7150-Y.

2.21 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 22 Sections. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category. Stencils, hand printed, painted, and felt pen markers are not acceptable.

B. Plastic Pipe Markers:
   1. Pre-tensioned Pipe Labels: Precoiled, semi-rigid plastic formed to partially or fully cover the circumference of pipe, or insulated pipe, and to attach to pipe without fasteners or adhesive complying with ANSI A13.1. Minimum letter size shall be 1/2” high.
   2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape. Minimum letter size shall be 1/2” high.
   3. Insulation: Furnish 1” thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2” beyond each end of plastic pipe marker.
   4. Arrows: Point each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
   5. Pipe Label Color Schedule:
      a. Domestic Cold Water piping:
         1) Background Color: Green.
         2) Letter Color: White.
      b. Domestic Hot Water Supply and Domestic Hot Water Recirculation piping:
         1) Background Color: Yellow.
         2) Letter Color: Black.
      c. Sanitary Sewer, Storm Drainage and Vent piping:
         1) Background Color: Green.
         2) Letter Color: White.

C. Valve Tags:
   1. Brass Valve Tags: Provide 1-1/2" diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4” high letters and sequenced valve numbers 1/2” high, and with 5/32” hole for fastener. Fill tag engraving with black enamel.
   2. Plastic Laminate Valve Tags (indoors only): Provide 3/32” thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32” hole for fasteners.
   3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

D. Access Panel Markers: Provide 1/16” thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve.

E. Plastic Equipment Signs:
   1. Provide 3” x 5” (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering. Minimum letter size shall be 1/2” high.
   2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
   3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
      a. Name and plan number.
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters, such as pressure drop, entering and leaving conditions, rpm, etc.
   4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2” x 11” bond paper, tabulate each equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

F. Underground-Type Plastic Line Markers: Provide 6” wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.

G. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Inc., or Brimar.

2.22 ELECTRICAL

A. General:
1. All electrical material, equipment, and apparatus specified herein shall conform to the requirements of Division 26.
2. Provide all motors for equipment specified herein. Provide motor starters, controllers, and other electrical apparatus and wiring which are required for the operation of the equipment specified herein.
3. Set and align all motors and drives in equipment specified herein.
4. Provide expanded metal or solid sheet metal guards on all V-belt drives to totally enclose the drive on all sides. Provide holes for tachometer readings. Support guards separately from rotating equipment.
5. Provide for all rotating shafts, couplings, etc., a solid sheet metal, inverted "U" cover over the entire length of the exposed shaft and support separately from rotating equipment. Cover shall extend to below the bottom of the shaft and coupling, and shall meet the requirements of the State Industrial Safety Regulations.
6. Specific electrical requirements (i.e., horsepower and electrical characteristics) for plumbing equipment are scheduled on the Drawings.

B. Quality Assurance:
1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for location and use - no exceptions.

C. Motors:
1. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment Specifications.
2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Unless otherwise noted on plans, all motors ½ HP or larger shall be rated for 208 or 460 volt, 3-phase, operation. Unless otherwise noted on plans, all motors less than 1/2 HP shall be rated for 120 volt, single phase operation.
4. Temperature Rating: Motor meets class B rise with class F insulation.
5. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
6. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.
   a. Frames: NEMA Standard No. 48 or 56; use driven equipment manufacturer's standards to suit specific application.
   b. VFD driven motors. To be provided rated for inverter duty (NEMA Standard MG-1, Part 31) and equipped with a shaft grounding device or as an insulated bearing motor.
   c. Bearings:
      1) Ball or roller bearings with inner and outer shaft seals.
      2) Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
      3) Designed to resist thrust loading where belt drives or other drives product lateral or axial thrust in motor.
      4) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
      5) Enclosure Type:
         a) Open drip-proof (ODP) motors for indoor use in clean air environments.
         b) Totally enclosed fan cooled (TEFC) motors for outdoor use and indoor application in dirty environments.

c) Totally enclosed air over (TEAO) motors for motors in the airstream of cooling towers and fluid coolers.
d) Guarded drip-proof motors where exposed to contact by employees or building occupants.
e) Weather protected Type I for outdoor use, Type II where not housed.

d. Overload Protection: Built-in thermal overload protection where external overload protection is not provided and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
e. Noise Rating: "Quiet."
f. Efficiency:
1) Motors shall have a minimum efficiency per governing State or Federal codes, whichever is higher.
2) And, motors shall meet the NEMA premium efficiency standard.
g. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

D. Starters and Electrical Devices:
1. Motor Starter Characteristics:
a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs.
b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
2. Manual switches shall have pilot lights and all required switch positions for multi-speed motors. Overload Protection: Melting alloy or bi-metallic type thermal overload relays, sized according to actual operating current (field measured).
3. Magnetic Starters:
a. Heavy duty, oil resistant, hand-off-auto (HOA), or as indicated, and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
b. Trip-free thermal overload relays, each phase, sized according to actual operating current (field measured).
c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division 23 Controls sections.
d. Built-in primary and secondary fused control circuit transformer, supplied from load side of equipment disconnect.
e. Externally operated manual reset.
f. Under-voltage release or protection for all motors over 20 hp.
4. Motor Connections: Liquid tight, flexible conduit, except where plug-in electrical cords are specifically indicated.

E. Low Voltage Control Wiring:
1. General: 14 gauge, Type THHN, color coded, installed in conduit.
2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp., Senator Wire and Cable Co., or Southwire Co.

F. Disconnect Switches:
1. Fusible Switches: For equipment 1/2 HP or larger, provide fused, each phase; heavy duty; horsepower rated; spring loaded quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; capacity and characteristics as indicated.
2. Non-Fusible Switches: For equipment less than 1/2 horsepower, switch shall be horsepower rated; toggle switch type with thermal overload quantity of poles and voltage rating as required.

PART 3 - EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal or otherwise irregular work, unless so indicated on Drawings or approved by Owner's Representative.

C. Install all items specified in this section of the Specification under the full purview of local and state governing agencies.

3.2 PERFORMANCE OF WORK

A. Examine areas, physical conditions and phasing requirements under which materials are to be installed. Layout the system to suit the different types of construction and equipment as indicated on the drawings.

B. Work shall start immediately after authorization has been given to proceed so that the overall progress of the construction is not delayed. No foundry items to be installed until submittals have been approved.

C. Coordinate with other trades as necessary to properly interface components of the plumbing system.

D. Follow manufacturer's directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the drawings or covered in these Specifications.

E. The omission from the drawings or Specifications of any details of construction, installation, materials, or essential specialties shall not relieve the Contractor from furnishing the same in place for a complete system.

3.3 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles provided on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.4 INSTALLATION

A. Coordinate the work between the various Plumbing Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision, coordination or failure to make proper and timely provisions, the alterations shall be made to the satisfaction of the Owner's Representative and at the Contractor's cost.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defective materials.

3.5 SUPPORTS AND HANGERS

A. Prior to installation of hangers, supports, anchors, and associated work, installer shall meet at project site with all trades and testing agency representatives to coordinate work associated with placement of such work.

B. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion

joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms. Where gypcrete is indicated, install reinforcing bars through opening at top of inserts.

C. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

D. Install hangers, supports, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

E. Install hangers within 12 inches of every change in piping direction, end of pipe run or concentrated load, and within 36 inches of every major piece of equipment. Hangers shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one hanger is required.

F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

G. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

H. Horizontal Hanger Spacing in accordance with following minimum schedules (other spacings and rod sizes may be used in accordance with the SMACNA Seismic Restraint Manual using a safety factor of five):

1. Cast Iron:

Pipe Size	Max. Hanger Spacing	Rod Size
Up to 4”	Each joint, 10 feet max	3/8"
6” and larger	Each joint, 10 feet max	1/2"

2. Steel Pipe (Water Filled):

Pipe Size	Max. Hanger Spacing	Rod Size
1/2" to 1-1/4"	5 feet	3/8"
1-1/2" to 2"	7 feet	3/8"
2-1/2" to 3"	10 feet	1/2"
4" and larger	10 feet	5/8"

3. Copper Pipe:

Pipe Size	Max. Hanger Spacing	Rod Size
1/2" to 1-1/2"	6 feet	3/8"
2" and larger	8 feet	1/2"

4. Plastic/Fiberglass Pipe:

Pipe Size	Max. Hanger Spacing	Rod Size
1/2" to 1"	3 feet	3/8"
1-1/4" and larger	4 feet	3/8"

5. Caulked Bell and Spigot and Glass Pipe: Provide hanger for each section of pipe, located at shoulder of bell. Where an excessive number of fittings are installed between hangers, provide additional reinforcing.

I. Vertical Support Spacing in accordance with following minimum schedules:

1. Cast Iron:

Pipe Size	Max. Vertical Support Spacing
All sizes	Base and each floor, not to exceed 15 feet

2. Steel Pipe (Water Filled):

Pipe Size	Max. Vertical Support Spacing
All sizes	Base and every other floor, not to exceed 25 feet

3. Copper Pipe:

Pipe Size	Max. Vertical Support Spacing
All sizes	Base and each floor, not to exceed 10 feet

4. Plastic/Fiberglass Pipe:

Pipe Size	Max. Vertical Support Spacing
All sizes	Base and each floor, not to exceed 10 feet

J. Sloping, Air Venting, and Draining:
1. Slope all piping as specified and as indicated, true to line and grade, and free of traps and air pockets. Unless indicated otherwise, slope piping in the direction of flow as follows:

Service	Inclination	Slope
Domestic Water	Down	1" per 100'
Soil and Waste	Down	1/4" per foot
Storm Water	Down	1/4" per foot
Sanitary Vent	Up (towards roof terminal)	1/4" per foot

2. Provide drain valves and hose adapters at all low points in piping.

K. Provisions for Movement:
1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.
3. Insulated Piping: Comply with the following installation requirements:
   a. Clamps: Attach clamps, including spacers, (if any), to piping with clamps projecting through insulation.
   b. Shields: Where low compressive strength insulation or vapor barriers are indicated on cold water piping, install shields or inserts.
   c. Saddles: Where insulation without vapor barrier is indicated install protection saddles.

L. Installation of Anchors:
1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends.

M. Equipment Supports:
1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction.
2. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.

N. Adjusting:
1. Hanger Adjustment: Adjust hangers so as to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.6 WALL, FLOOR, AND ROOF PENETRATION SIZING

A. All pipe penetrations through rated and non-rated assemblies shall be sized to allow for compliance with structural integrity and fire ratings, as applicable. Where sleeves are required, the sleeve size shall be installed with the inside clear diameter providing clearances as required below.
1. Uninsulated pipe penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1” (minimum) to 2” (maximum) larger than the outside diameter of each uninsulated pipe.
2. Insulated pipes penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1” (minimum) to 2” (maximum) larger than the outside diameter of each insulated pipe.
3. Uninsulated pipe penetrations through fire rated walls and floors, and through roof: penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each uninsulated pipe to provide minimum 1/4” annular space between the outside of the pipe surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
4. Insulated pipe penetrations through fire rated walls and floors, and through roof: pipe penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each insulated pipe to provide minimum 1/4” annular space between the outside of the insulation surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
5. Uninsulated pipe penetrations through foundation and basement walls: penetration sizes shall be larger than the outside diameter of each uninsulated pipe to allow adequate space for installation of mechanical link seals. Coordinate with specific manufacturer requirements.

3.7 WALL AND PIPE SIZING COORDINATION

A. Pipes routed horizontally or vertically in framed wall enclosures shall be limited to sizes that fit within the available free area without impacting the construction of the wall or intent of architectural floor plans. Maximum piping diameters shall be adjusted as necessary to accommodate insulation, fittings and pipe crossings inside the wall enclosure. Sizing is based on the following criteria:
1. 3-5/8” Stud Wall: Maximum 2” diameter piping.
2. 4” Stud Wall: Maximum 3” diameter piping.
3. 6” Stud Wall: Maximum 4” diameter piping.

3.8 WATER HAMMER ARRESTERS

A. Install as per PDI WH-201 Standard and equipment manufacturer’s recommendation and as shown on working drawings.

B. Provide before each quick closing valve, including but not limited to, flush valves, solenoid valves, electronic trap primers, pre-rinse faucets, dishwashers and banks of fixtures.

C. Water hammer arrestors shall only be installed in the upright position above the piping.

D. Install at each plumbing fixture, bank of fixtures, equipment and as indicated on the plans.

E. Where water hammer arrestor are installed in walls or above ceilings provide access panels as required for future maintenance. Coordinate locations with Architect or Owner’s Representative prior to installation or water hammer arrestor and access doors.

F. Water hammer arrestors shall be sized based on the PDI WH-201 Standard method as follows:

Water Hammer Arrestor Sizing	
PDI Size Rating	Fixture Units Served
A	1-11
B	12-32
C	33-60
D	61-113
E	114-154
F	155-330

3.9 ROOF CURBS, EQUIPMENT RAILS, PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed.

C. Verify roof insulation thickness and adjust cant to match.

3.10 PIPING INSTALLATION

A. The word “piping” shall mean all pipes, fittings, nipples, valves and all accessories connected thereto.

B. Run piping generally parallel to the axis of the building, arranged to conform to the building requirements and to suit the necessities of clearance for other mechanical ducts flues, conduits and work of other trades and close to ceiling or other construction as practical, free of unnecessary traps or bends.

C. Run horizontal sanitary drainage at uniform pitch of not less than 1/8" per foot, unless otherwise indicated. Pitch horizontal vent piping downward from stack to fixtures.

D. Ream or file each pipe to remove burrs. Inspect each length of pipe and each fitting for workmanship and clear passageway.

E. All piping shall be inspected for defects and flaws prior to installation. Remove any damaged piping from job site. Piping shall be thoroughly cleaned of dirt, debris or rust.

F. Cleanouts to be provided at each change in direction greater than 135° or 100' maximum intervals on underground piping.

G. Cleanout elevations shall be mounted flush with finished floor elevation.

H. Cleanouts to be same size as pipe except cleanout plugs larger than 4" shall not be required.

I. Cleanouts on concealed piping to be extended through and terminate flush with the finished wall or floor. Cover plates to be provided on all cleanout plugs in finished areas.

J. The bodies of cleanout ferrules to conform in thickness to that required for pipe and fittings of the same metal.

K. Mount piping on roof to manufactured polypropylene pipe supports: Caddy Pyramid, Roof Top Blox or equal.

3.11 VIBRATION CONTROL ISOLATORS

A. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

B. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

C. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

D. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

F. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.12 ELECTRICAL COORDINATION

A. Division 22 installers shall coordinate with Division 26 work to provide complete systems as required to operate all mechanical devices installed under this Division of work.

B. Installation of Electrical Connections: Furnish, install, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, etc., motors and controls in accordance with the drawings and in accordance with equipment manufacturer’s written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC, and NECA’s “Standard of Installation” to ensure that products fulfill requirements.

C. Division 22 has responsibilities for electrically powered plumbing equipment which is specified in Division 22 Specifications or scheduled on Division 22 Drawings as follows:
   1. Motors: Furnish and install all motors necessary for mechanical equipment.
   2. Magnetic Starters: Furnish all magnetic starters whether manually or automatically controlled which are necessary for mechanical equipment. Furnish these starters with all control relays or transformers necessary to interface with mechanical controls. If the starter is factory installed on a piece of Division 22 equipment, also furnish and install the power wiring between starter and motor.
   3. Variable Frequency Drives: Provide all VFD’s associated with fire protection equipment. If the drive is installed on a piece of factory assembled equipment the wiring between motor and drive is to be provided as part of the factory equipment.
   4. Disconnects: Provide the disconnects which are part of factory wired Division 22 equipment. Factory wiring to include wiring between motor and disconnect or combination starter/disconnect.
   5. Controls: Division 22 Contractor (including the Building Automation System (BAS) Controls subcontractor) is responsible for furnishing the following equipment in its entirety. This equipment includes but is not limited to the following:
      a. Control relays necessary for controlling Division 22 equipment.
      b. Control transformers necessary for providing power to controls for Division 22 equipment.
      c. Low or non-load voltage control components.
      d. Non-life safety related valve or damper actuators.
      e. Float switches.
      f. Solenoid valves, EP and PE switches.
      g. Communications wiring and conduit between control devices and plumbing equipment.
      h. Raceway to support control cabling.

D. Division 26 Electrical Responsibilities:
   1. Motors: Provide the power wiring for the motors from servicing panel to motor controller.
   2. Magnetic Starters: Except where magnetic starters are factory installed on Division 22 factory assembled equipment, Division 26 is to install magnetic starters furnished by Division 22 and install the necessary power wiring to the starter and from the starter to the motor. In the case of factory installed starters, Division 26 is to install the necessary power wiring from source panel/disconnect to the starter.
   3. Variable Frequency Drives: Provide the necessary power wiring to the VFD and from the VFD to the motor except in the case of factory installed VFD's where wiring between the motor and VFD is to be by Division 22.
   4. Disconnects: Provide all disconnects necessary for Division 22 equipment which are not provided as part of factory wired Division 22 equipment. Provide power wiring to all disconnects. In addition provide power wiring between motor and disconnect when the disconnect is not factory installed.
   5. Controls: Division 26 is responsible for providing power to control panels and provide final power connection to Division 22 provided control transformers.
   6. Fire Sprinkler System: Division 26 is responsible for providing power wiring to fire protection controls including flow switches and alarm bells.
   7. Specialized fire suppression systems: Division 26 is responsible for providing power wiring to suppression system and its controls.

E. Motors and Motor Control Equipment: Conform to the standards of the NEMA. Equip motors with magnetic or manual line starters with overload protection. Motor starters and line voltage controls shall be installed under Electrical Section but located and coordinated as required under this Section of the work. Starters shall be combination type with non-fusible disconnect switches. All single phase fractional horsepower motors shall have built-in overload protection.

3.13 PAINTING

A. All painting shall be provided under this Division work, unless otherwise specified under Division 9: Painting. Painting schemes shall comply with ANSI A13.1. Paint all exposed materials such as piping, equipment, insulation, steel, etc. Exposed copper indirect waste piping serving food service equipment shall be painted metallic chrome.

B. All exposed work under Division 22 shall receive either a factory finish or a field prime coat finish, except:
   1. Exposed copper piping.
   2. Aluminum jacketed outdoor insulated piping.

3.14 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment. Identification is not required inside wall assemblies or under concrete slabs.

B. Piping System Identification:
   1. Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.
   2. Locate pipe markers as follows:
      a. Near each valve and control device.
      b. Near each branch, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
      c. Near locations where pipes pass through walls, floors, ceilings, or inaccessible enclosures.

d. At access doors, manholes, and similar access points which permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.
f. Spaced horizontally at maximum spacing of 50' along each piping run, with minimum of one in each room. Vertically spaced at each story traversed.

3. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipe where flow is allowed in both directions.
4. Provide pipe identification on:
   a. Domestic cold water.
   b. Domestic hot water.
   c. Sanitary sewer and vent piping.
   d. Storm drainage piping.

C. Valve Tag Identification: Install tags on valves and control devices in piping systems, except at check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
1. Provide valve tags for:
   a. Domestic cold water.
   b. Domestic hot water

D. Plumbing Equipment Identification: Locate engraved plastic laminate signs on or near each major item of plumbing equipment and each operational device. Additional labels are not required if systems are properly labeled by equipment manufacturers.
1. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.
2. Provide signs for the following equipment:
   a. Main control and operating valves, including safety devices.
   b. Water heaters and similar equipment.
   c. Tanks and pressure vessels.
   d. Strainers, filters, treatment systems and similar equipment.

E. Underground Piping Identification: During backfilling/topsoiling of each exterior underground piping system, install one underground-type plastic line marker, located directly over buried line at 6” to 8” below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16”, install single line marker. Identification is only required on piping to five feet outside the building perimeter. Underground piping identification is not required below concrete slabs.

3.15 CLEANING EQUIPMENT AND MATERIALS

A. In addition to the requirements of Section 220500, provide for the safety and good condition of all materials and equipment until final acceptance by the Owner’s Representative. Protect all materials and equipment from damage. Provide adequate and proper storage facilities during the progress of the work. Special care to be taken to provide protection for bearings, open connections, pipe coils, pumps, compressors, and similar equipment.

B. All piping, finished surfaces, and equipment to have all grease, adhesive labels, and foreign materials removed.

C. All piping to be drained and flushed to remove grease and foreign matter. Pressure regulating assemblies, traps, flush valves, and similar items shall be thoroughly cleaned. Remove and thoroughly clean and reinstall all liquid strainer screens after the system has been in operation for ten days.

D. When connections are to be made to existing systems, the Contractor is to do all cleaning and purging of the existing systems required to restore them to the condition existing prior to the start of work.

3.16 TESTING

A. Provide all tests specified herein, in other Division 22 Sections, and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner's Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Owner's Representative to witness all field tests and conduct all field inspections. The Contractor to give the Owner's Representative ample notice of the dates and times scheduled for tests. Any deficiencies to be completely retested at no additional cost.

C. Inspection to continue during installation and testing. Perform a final inspection of the equipment prior to installation to determine conformity to the type, class, grade, size, capacity, and other characteristics specified herein or indicated. Correct or replace all rejected equipment prior to installation.

3.17 DISINFECTING - PLUMBING SYSTEMS

A. Disinfection of potable water distribution system shall be as prescribed by the local health authority or the following minimum requirement. After pressure tests have been made thoroughly flush the entire domestic water distribution system with water until all entrained dirt and mud have been removed, and sterilize by chlorinating material. The chlorinating material shall be liquid chlorine. The chlorinating material shall provide a dosage of not less than 50 parts per million and shall be introduced into the system or part thereof in an approved manner. Retain the treated water in the pipe for 24 hours, or, fill the system or part thereof with a water-chlorine solution containing at least 200 parts per million of chlorine and allow to stand for three (3) hours. Open and close all valves in the system being disinfected three times during the contact period. Then flush the system with clean potable water until the residual chlorine is reduced to less than 1.0 ppm. During the flushing period open and close all valves and faucets three times. From at least three divergent points in the system, take samples of water in properly sterilized containers for bacterial examination. Repeat the disinfecting until tests indicate that satisfactory bacteriological results have been obtained.

B. Taking of samples shall be witnessed by Owner's Representative. Samples are to be taken and tested by an independent analytical testing laboratory. Written reports shall be supplied to Owner's Representative for approval.

3.18 OPERATING TESTING AND CERTIFICATION - PLUMBING SYSTEMS

A. Upon completion and disinfection, and prior to acceptance of the installation, the Contractor to subject the plumbing system to operating tests to demonstrate satisfactory, functional, and operating efficiency. Such operating tests to include the following information in a report with conclusions as to the adequacy of the system.
   1. Time, date, and duration of tests.
   2. Water pressures at most remote location.
   3. Operation of all valves and hydrants.
   4. Operation of all floor drains by flooding with water.
   5. Quality of domestic water.
   6. Read all indicating instruments at half-hour intervals unless otherwise directed. Supply four copies of the test report to the Owner's Representative.

END OF SECTION 220500

SECTION 220548

VIBRATION ISOLATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. All plumbing piping and equipment as noted on the equipment schedules or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

B. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All plumbing piping and equipment as noted on the equipment schedules, in the specification or as required by code shall be designed to resist seismic forces. Refer to Section 220548 Seismic Restraint for Piping and Equipment

D. This Section includes the following:
1. Vibration Isolation pads.
2. Spring isolators.
3. Housed seismic spring vibration mounts.
4. Vibration isolation equipment bases.
5. Flexible piping connectors

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 220549: Seismic Restraint for Piping and Equipment

1.3 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. IBC: International Building Code with State Amendments.

C. ICC-ES: ICC-Evaluation Service.

1.4 CODES AND STANDARDS

A. Provide components conforming to the load requirements of the latest addition of the local building code and the following:
1. 2015 International Building Code with AHJ Amendments
2. American Society of Civil Engineers (ASCE):
   a. ASCE 7-10: Minimum Design Loads for Buildings and Other Structures
3. The Manufacturers Standardization Society (MSS):
   a. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
   b. MSS SP-69: Pipe Hangers and Supports - Selection and Application.
   c. MSS SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices
   d. MSS SP-127: Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application.
4. Mason West Inc. Seismic Restraint Guidelines 2014 Edition
   a. OPM-0043-13 for all suspended piping, suspended ductwork and suspended electrical raceways

1.5 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
1. Seismic forces for new installations are determined per ASCE/SEI 7-05. Refer to Structural Design for seismic factors and design criteria. Select and submit appropriate values for each piece of equipment and sub-system and material type for the project, and base the seismic calculations on these values.
2. Refer to Section 220549 Seismic Restraint for Piping and Equipment for seismic specific requirements.
3. Coordinate all seismic and load requirements with the registered professional Structural Engineer.

B. Component Importance Factor:
1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
2. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7-10 Section 13.1.3 regardless of Risk Category. Components include, but are not limited to the following:
a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established y the authority having jurisdiction and is sufficient to pose a threat to the public if released.

1.6 QUALITY ASSURANCE

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

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

C. Building Structural Limits: The design of supports and restraints shall not exceed the building structure allowable point loads. Coordinate all work with the registered professional Structural Engineer.

D. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

1.7 SUBMITTALS

A. Product Data shall include the following:
1. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
2. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
3. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
4. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service or agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
1. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
2. Provide all details of suspension and support for ceiling hung equipment.
3. Where walls, floors, slabs or supplementary steel work are used for seismic restraint the locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
4. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and where required wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads. Provide base with level top surfaces with integral sloping on bottom to match support structure.

D. Coordination Drawings: Show coordination and plan locations of seismic bracing for HVAC piping, ductwork, and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Qualification Data: Devices shall be selected to meet seismic and support requirements by a registered professional Structural Engineer.

F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent test agency.

G. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS AND APPLICATION

A. Factory Finishes:
1. Standard paint applied to factory-assembled equipment before shipping.
2. Powder coating on springs and housings.
3. All hardware shall be galvanized or powder coated.
4. Hot-dip galvanized or powder coating of metal components for exterior use.
5. Baked enamel or powder coat for metal components for interior use.

B. Glumac Device Key Schedule: Part 3 of this Section schedules the application of devices described in Part 2 for use with plumbing equipment found on this project. The tag designation of preferred devices is as follows:

Glumac Isolator Tag	Description
P-1	Vibration isolation waffle pad
G-1	All-directional pipe anchor
G-2	Vertical pipe guide
G-3	Horizontal thrust restraint
SB-1	Sway bracing
F-1	Kevlar/rubber spherical type flexible piping coupling
F-2	Stainless hose flexible piping coupling
F-3	Flexible expansion joints

2.2 VIBRATION ISOLATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:
1. Mason, basis of selection or equal by
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Kinetics Noise Control.
5. Vibration Eliminator Co., Inc.
6. Vibration Isolation.
7. Vibration Mountings & Controls, Inc
8. Vibro-Acoustics, Inc
9. Vibrex

B. P-1 Style: Neoprene pads shall consist of a 3/4" (19 mm) thick neoprene pad molded in square waffle modules, a minimum 1/4" (6 mm) thick steel load distribution plate and 3/4" (19 mm) hole with a neoprene anchor bolt bushing with a flat washer face. Pads may be single or multiple layers as required for leveling. Pads shall be Mason #MBSW Series or equal.

2.3 FLEXIBLE PIPING CONNECTORS

A. F-1 Style: Flexible spherical expansion joints for pump connections. Shall employ peroxide cured EPDM in the covers, liners and Kevlar tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16" to 24" may be single sphere. Sizes 3/4" to 1 1/2" may have threaded bolted flange assemblies, one sphere and cable retention. 14" and smaller connectors shall be rated at 250 psi up to 190F with a uniform drop in allowable pressure to 190 psi at 250F. 16" and larger connectors are rated 180 psi at 190F and 135 psi at 250F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Manufacturer shall provide pre-stretching charts for expansion joints when used in conjunction with isolated equipment. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2" thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be Mason #SAFEFLEX SFDEJ Series, #SAFEFLEX SFEJ Series, #SAFEFLEX SFDCR Series or #SAFEFLEX SFU Series and Control Rods Mason #CR.

B. F-2 Style: Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" (75 mm) and larger shall be flanged. Smaller sizes shall have male threaded nipples or copper sweat ends. Hoses must have sufficient length, minimum 12” (300 mm) long, to accept 1/2” (12 mm) intermittent motion without failure. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Mason #FFL Flanged Series, #CPSB Copper Sweat Series or #CSAMN Threaded Series

C. F-3 Style: Flexible Vee or U-bend braided hose across building or expansion joints. Piping and equipment connections shall be protected against seismic damage by the insertion of braided flexible hose Vee assemblies rated for ±4” (100mm) seismic motion in all planes. Should the application include ±6” (150mm) thermal movement or thermal movement alone, install the Vee so the thermal movement is axial. Vees shall have a minimum burst pressure of four times their rated pressure. Vees in steel lines shall have stainless hose and braid. Copper lines, bronze hose and braid. Guiding and anchoring shall be as recommended by the manufacturer. 60° Vees shall be Mason #VFL flanged braided steel Series, #VMN Threaded Braided Stainless Steel Series or #VCPSB Copper Sweat Series.

2.4 BRACING DEVICES FOR EQUIPMENT, PIPING, AND DUCTWORK.

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
2. California Dynamics Corporation
3. Cooper B-Line, Inc.
4. Hilti, Inc.
5. Kinetics Noise Control
6. Loos & Co.
7. Mason Industries
8. Tolco Incorporated
9. Unistrut
10. ISAT, Inc
11. Vibro-Acoustics, Inc.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least two (2) times the maximum seismic forces to which they will be subjected.

C. Bushings for Floor-Mounted Equipment Anchorage: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

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

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488. Minimum length of eight times diameter.

G. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 LOCATION AND APPLICATION OF VIBRATION ISOLATION EQUIPMENT

A. The following Tables provide schedules for vibration devices required for isolation of plumbing equipment provided on the project. Refer to Part 2 above for device specifications.

B. Pumps – Equipment Isolation

TABLE 1: EQUIPMENT ISOLATION SCHEDULE – PUMPS

EQUIPMENT	LOCATION								
	CRITICAL ROOF OR FLOOR (35' - 50' SPAN)			UPPER STORY (20' - 35' SPAN)			ON GRADE		
	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE
PUMPS									
Up to 5 HP	P-1	0.15	NA	P-1	0.15	NA	P-1	0.15	NA

Notes:
(1) Alternate: Factory installed by equipment manufacturer.
(2) Provide full perimeter steel welded frame below equipment
(3) Provide support per manufacturer's recommendation
(4) Provide F-1 flexible connector for all high horsepower pumps, F-2 connector for fractional horsepower pumps.

3.2 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.3 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service or agency acceptable to authorities having jurisdiction. Indicate on Drawings, by details, schedules, or a combination of both, the locations where hanger rods for individual pipes and hanger rods for trapeze hangers require hanger rod stiffeners.

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

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

3.4 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

C. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

D. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

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

F. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

G. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

H. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

I. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

J. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

K. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

L. Equipment Restraints:
   1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
   2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
   3. Install seismic-restraint devices using methods approved by an evaluation service or agency acceptable to the authorities having jurisdiction. Provide required submittals for components.

M. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet (12m) and longitudinal supports a maximum of 80 feet (24m).
   3. Brace a change of direction longer than 12 feet (3.7m).

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

O. Install seismic-restraint devices using methods approved by an evaluation service or agency acceptable to the authorities having jurisdiction, providing required submittals for component.

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

Q. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

R. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

S. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the Structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

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

3.6 ADJUSTING

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

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

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

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

END OF SECTION 220548

SECTION 22 05 49

SEISMIC RESTRAINT FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Seismic restraint and support of piping and plumbing equipment as required by code and as designed by project registered professional Structural Engineer.
   2. Mechanical component supports and the means by which that are attached to the mechanical component shall be designed for the forces and displacements determined in ASCE 7-10 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.

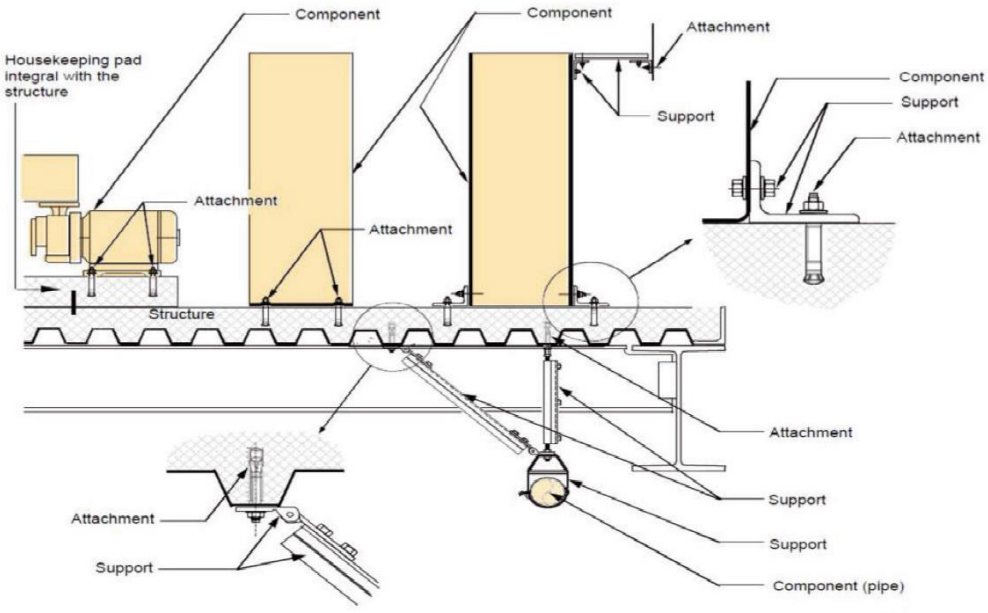
1.2 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. IBC: International Building Code with AHJ Amendments.

C. ICC-ES: ICC-Evaluation Service.

D. Mechanical Components: Examples of attachments and supports for a variety of mechanical components are shown as follows:



E. Mechanical Supports: Those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

F. Mechanical Attachments: Means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 220548: Vibration Isolation for Piping and Equipment

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Structural Performance: Restraint devices and systems shall withstand the effects of locally defined gravity loads, seismic loads, dead loads, live loads, winds loads and stresses within limits and under conditions indicated according to the Building Code and ASCE 7. Coordinate all support structures and restraint systems with project registered professional Structural Engineer.

C. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

D. Codes and Standards: Provide components conforming to the seismic load requirements of the latest addition of the local building code and the following:
   1. International Building Code with State Amendments.
      a. For MEP nonstructural supports the design is based on selection of the proper Component Importance Factor as defined below based on the Risk Category selected for the building. The assignment of Risk Category of Buildings per Table 1604A.5 or Seismic Design Category are related to structural design of the building itself and not based on the nonstructural attachments. The Risk Category takes into account multiple factors including occupancy, seismic, wind loading, ice, flood, and snow loading. The Seismic Design Category is based on the desired Risk Category and the design earthquake ground motion at the site.
      b. Restraint forces associated with nonstructural attachments to a building structure must be performed by a registered design professional engaged in performance of this type of design work. This may include Architects, Civil Engineers or Structural Engineers, but typically Structural Engineers. Mechanical Engineers are only licensed to perform mechanical engineering design per the Professional Engineers Act. Nonstructural attachments require detailed structural calculations and typically involve component weights that exceed 400 lbs within 4' of the floor or exceed 20 lbs. and suspended from structure above.
      c. IBC Section 1705.12.3: Seismic certification of nonstructural components. The registered design professional (this can include M&E engineers) shall specify on the construction documents the requirements for certification by analysis, testing or experience data for nonstructural components and designated seismic systems in accordance with Section 13.2 of ASCE 7, where such certification is required by Section 1705.12.)
      d. Section 1613: Standard Occupancies
   2. American Society of Civil Engineers (ASCE):
      a. ASCE 7-10 - Minimum Design Loads for Buildings and Other Structures

3. Mason West Inc., Seismic Restraint Guidelines
    a. OPM-0043-13 for all suspended piping.

1.5 PERFORMANCE REQUIREMENTS

A. Component Importance Factor:
1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
2. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7-10 Section 13.1.3 regardless of Risk Category. Components include, but are not limited to the following:
    a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
    b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established y the authority having jurisdiction and is sufficient to pose a threat to the public if released.

1.6 SUBMITTALS

A. Product Data:
1. Include rated load, rated deflection, and overload capacity for each device or system.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service or agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Submit seismic brace product details from the Mason West Seismic Restraint Guidelines detailing compliance with the specifications.
4. Where products from the Mason West Seismic Restraint Guidelines cannot be used, special details must be submitted for approval.

B. Seismic Restraint Calculations
1. Where seismic restraint sizes, spacing and anchorage are included in the Mason West Seismic Restraint Guidelines no further calculations are required.
2. Where additional information is required:
    a. Seismic restraint calculations must be provided for all connections to the structure.
    b. Calculations must be stamped by a registered professional Structural Engineer.

1.7 ENGINEERED PIPING SYSTEMS

A. Where the piping system design indicated on the plans utilizes Mason Industries, Inc. - Mason West, Inc. seismic restraint components, vibration isolators, guides, anchors, expansion compensators and flexible connectors the following requirements apply:
1. Mason Industries, Inc. - Mason West, Inc. products must be installed as shown.
2. If product substitutions or design changes are made the contractor must provide certified design of the piping system and meet the following conditions:
    a. Certification must be provided by a registered professional Structural Engineer.
    b. Certification shall include a statement that all systems have been checked for loads and stresses and that no excessive loads or stresses exist.
    c. Forces on all anchors, guides, supports, and restraints must not exceed those shown in the original design unless the structure is checked for the larger loads at no cost to the owner.

B. Where the piping system design is not indicated on the drawings the design is delegated to the contractor with the following requirements for piping certification and analysis:
   1. The supports, anchors, guides and seismic braces for systems with significant thermal motion including steam, condensate, high temperature hot water and heating hot water systems must be designed for combined gravity, seismic, pressure and thermal loads.
   2. Small diameter pipes (2” diameter and smaller) may not require analysis as determined by the project registered professional Structural Engineer.
   3. The results of the analysis shall include reactions at restraints and anchors, maximum pipe displacements and a code compliant report indicating maximum pipe stresses.
   4. Where required, seismic restraint components, vibration isolators, guides, anchors, expansion compensators and flexible connectors manufactured by Mason Industries, Inc. and Mason West, Inc. shall be incorporated into the design of the systems.
   5. The analysis and design must be performed by a Structural Engineer with 5 years of experience in this field.

1.8 MANUFACTURER AND CONTRACTOR RESPONSIBILITIES

A. All seismic restraints shall be designed by a registered professional Structural Engineer.

B. Seismic restraint layouts for piping shall be added to the contractor’s shop drawings and shall include:
   1. The number, size and location of seismic braces.
   2. Maximum support loads and seismic loads at the seismic brace locations.
   3. Reference to specific details or pages from the Mason West Seismic Restraint Guidelines.

C. Installations not addressed by the state pre-approval process must be designed, detailed and submitted along with the shop drawings.

D. Submit seismic restraint layout drawings and special details for approval of the project registered professional Structural Engineer per the requirements listed in the Mason West Seismic Restraint Guidelines.

E. Seismic restraint layout drawings shall bear the stamp and signature of the registered professional Structural Engineer who designed the layout of the braces.

1.9 LOADS ON STRUCTURE

A. The responsibility of determining allowable loads on the structure is the sole responsibility of the project registered professional Structural Engineer.

B. Maximum support loads and seismic brace loads on the structure must be less than the maximum allowable loads defined by the project registered professional Structural Engineer, as shown on the plans.

C. Where maximum loads are not listed on the plans or the maximum allowable loads cannot be met, any additional support steel required to reduce support and seismic bracing loads on the structure shall be designed by the project registered professional Structural Engineer.

D. Mechanical component supports and the means by which that are attached to the component shall be designed for the forces and displacements determined in ASCI 7-10 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.

E. Mechanical supports are those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

F. Mechanical attachments are the means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

PART 2 - PRODUCTS

2.1 INTENT

A. All seismic restraints described in this section shall be the product of a single manufacturer.

B. Mason Industries products are the basis of these specifications; products of other manufacturers may be submitted for review provided their systems strictly comply with the specifications.

2.2 SEISMIC SWAY BRACING

A. Seismic sway braces shall consist of galvanized steel aircraft cables, steel angles or steel struts.

B. Cables braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads. Brace end connections shall be steel assemblies that swivel to the final installation angle.

C. Cable brace assemblies shall have published strength and stiffness ratings based on testing per FM-1950 standards.

D. Angle or strut bracket assemblies shall be FM Approved except as noted below.

E. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps.

F. Cable brace bracket assemblies shall be Type SCB or SCBH. Solid brace bracket assemblies shall be Type SSB-FM, SSBS-FM or SHB-FM. All bracket assemblies shall have published strength and stiffness values based on testing per FM-1950.

G. Rod clamps shall be Type SRC or UCC.

H. All brace components shall be as manufactured by Mason Industries, Inc. and Mason West, Inc. as included in the Mason West Seismic Restraint Guidelines.

PART 3 - EXECUTION

A. Contractor’s Statement of Responsibility: Each contractor responsible for installing a Designated Seismic System or any seismic resisting component must submit a statement of responsibility prior to the commencement of work to include acknowledgment of awareness of the need for Special Inspections.

B. All seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

C. Installation of seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

D. No connections between the piping and the building structure shall be made that degrades the seismic restraint system herein specified.

E. Any conflicts with other trades due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner's Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

END OF SECTION 220549

SECTION 220593

PLUMBING TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 WORK RELATED IN OTHER SECTIONS

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 221000: Plumbing Piping, Valves and Specialties

C. Section 230593: Testing, Adjusting and Balancing (HVAC)

D. Division 26: Electrical.

1.2 SUMMARY

A. Scope: Extent of testing, adjusting and balancing work required by this Section is indicated on the drawings, in schedules, and by the requirements of this Section, and Section 230500 - Basic Mechanical Requirements.

B. Systems: Testing, adjusting and balancing specified in this Section shall include, but not be limited to, the following systems:
   1. Domestic pressure booster systems.

1.3 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Reference Standards
   1. ANSI/ASHRAE Standard 111 - Measurement, Testing, Adjusting and Balancing of Building HVAC Systems (current edition).
   2. ASHRAE - HVAC Applications Handbook: Chapter 38 - Testing, Adjusting and Balancing (current edition).
   3. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings, Chapter 6 (current edition).
   4. AABC - National Standards for Total System Balance.
   5. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
   6. Local Nonresidential Energy Code.

1.4 QUALITY ASSURANCE

A. Contractor’s Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 5 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, is not the installer of the system to be tested and is otherwise independent of the project. Testing, adjusting, and balancing shall be performed by a certified NEBB technician or a certified AABC technician under direct field supervision of a Certified NEBB Supervisor or a Certified AABC Supervisor. Testing and balancing agency must submit qualifications for review and approval prior to acceptance for work.

B. Penalty: The Contractor shall submit the name of the organization he proposes to employ for approval within 30 days after contract award. If the Contractor fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

C. Retainages: In addition to any other sums retained or withheld pursuant to the provisions of this Contract, the amount of dollars will be withheld from payments to the contractor until such time as the work has been completed and accepted. In no event will this amount be paid to the Contractor prior to 60 days following acceptance of the project; during such time, the Contractor shall investigate and correct any reported deficiencies unless such deficiencies are a result of unauthorized tampering by building occupants.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 6 months.

E. Testing and balancing agency, as part of its contract, shall act as authorized inspection agency responsible to Consulting Engineer and Owner, and shall list all items that are installed incorrectly, require correction, or have not been installed in accordance with contract Drawings and Specifications, pertaining to air distribution, cooling and heating systems. The testing and balancing agency is required to provide written reports of all deficiencies and proposed recommendations to the Owner' Representative, Contractor, Architect and Engineer.

F. The testing and balancing agency shall provide with his bid a performance guarantee covering all phases of the work as herein specified.

G. The General and Plumbing Contractors shall cooperate with the selected testing and balancing agency in the following manner:
   1. Provide sufficient time before final completion dates so that tests and balancing can be accomplished.
   2. The various system installers, suppliers and contractors shall provide all required materials, labor and tools to make corrections when required without undue delay. Install balancing valves as required by testing and balancing agency.
   3. The contractor shall put the domestic hot recirculation system and equipment into full operation and shall continue the operation of the same during each working day of testing and balancing.
   4. Testing and balancing agency shall be kept informed of any major changes made to the system during construction, and shall be provided with a complete set of Record Drawings.
   5. The General Contractor shall make space and other facilities available to the testing and balancing agency to enable their work to progress. The General Contractor shall schedule the work of other trades to avoid conflicts with this work.

1.5 SUBMITTALS

A. Conform to the Submittals requirements of Division 01.

B. Forms: The Contractor shall deliver a complete copy of either NEBB or AABC standard forms for testing and balancing work associated with the project. These forms shall serve as specific guidelines for producing final test report. Hybrid or non-standards forms are not acceptable.

C. Test Reports: Provide six (6) certified test reports, signed by the test and balance supervisor who performed the work. The final reports shall include key plans identifying location of all balancing valves and pumps. Final test reports shall be typed. Hand written reports are not acceptable.

D. Maintenance Data: Include, in maintenance manuals, copies of certified and approved test and balance reports and identification of instruments.

E. Qualifications: The Test and Balance Agency shall submit qualifications of all persons responsible for supervising and performing the on-site testing and balancing work and the name of the certifying engineer. Provide a reference list of five (5) similar size projects with contact person and telephone number.

1.6 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.
   1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.
   2. The agenda shall include a general description of each air and water system with its associated equipment and operation cycles for heating and cooling.
   3. The agenda shall include a list of all domestic hot water flows to be performed at all mechanical equipment.
   4. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date.

1.7 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met.
   1. Installation and start-up work on equipment or systems to be tested has been completed and documented.
   2. Work area scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.
   3. All related mechanical systems which may affect the operation of the system to be tested shall be at their normal operating conditions.

PART 2 - PRODUCTS

2.1 TEST INSTRUMENTS

A. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Owner’s Representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.

B. Additional Instruments: Permanently installed measuring instruments, such as temperature and pressure gauges, shall be checked against Certified Calibrated instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

PART 3 - EXECUTION

3.1 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required by approved project drawings and specifications.

B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.
   1. All instruments shall be applied in accordance with the manufacturer's certified instructions.
   2. All labor, instruments, and appliances required shall be furnished by the Contractor.

3.2 WATER SYSTEM PROCEDURES

A. Preparation:
   1. Open all valves to full open position.
   2. Check pump rotation.
   3. Check expansion tank(s) to determine they are not air bound and the system is completely full of water.
   4. Check all air vents at high points of water systems and determine that all are installed and operating freely.
   5. Operate each variable frequency drive (VFD) and verify controls installation is complete.
   6. Check that hot water heaters and heat exchangers are fully operational.
   7. Check that pressure regulating valves are operational over full range.

B. Metering: Water quantities and pressures shall be measured with calibrated meters.
   1. Venturi tubes, orifices, or other metering fittings and pressure gauges shall be used to measure water flow rates and balance systems.
   2. Systems shall be adjusted to provide the approved pressure drops through the heat transfer equipment (coils except room units, converters, etc.) prior to the capacity testing.

C. Automatic Controls: Automatic control valves shall be positioned for full flow through the heat transfer equipment of the system during tests.

D. Distribution: Adjustment of distribution shall be effected by means of balancing valves and automatic flow control valves as provided. Manual service valves shall not be used for balancing.
   1. Where automatic flow control valves are utilized in lieu of manual balancing valves, only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.

E. Water System Test and Balance Procedure: Perform the following tests, and balance each system in accordance with the following requirements:
   1. Set domestic recirculating pumps and associated balancing valves to proper gallons per minute delivery.
   2. Set pressure booster pumps and associated balancing valves to proper gallons per minute delivery.
   3. Adjust recirculation hot water flow at each branch.
   4. Coordinate with recirculation pump control system and record timeclock periods and setpoint.
   5. Test and record entering and leaving water temperatures through heat exchangers.
   6. Test and record entering and leaving water temperatures through central water distribution mixing valves (does not include fixture mounted mixing valves).
   7. Test, verify and record operation of domestic water pressure booster systems.
   8. Upon completion of flow readings and adjustments at balancing valves, mark all settings and record data.
   9. List all mechanical specifications of pumps.
   10. Rated and actual running amperage of pump motor.
   11. Adjust each pressure regulating valves and document final setpoint.

3.3 WATER SYSTEM DATA

A. Report: The certified report for reach water system shall include the data listed below.
   1. Pumps (Recirculating and Booster):
      a. Installation data
         1) Manufacturer and model
         2) Size
         3) Type drive
         4) Motor hp, voltage, phase, and full load amps

b. Design data
   1) GPM
   2) Head
   3) RPM
   4) Amps
c. Recorded data
   1) Discharge pressures (full-flow and no-flow)
   2) Suction pressures (full-flow and no-flow) operating head
   3) Operating gpm (from pump curves if metering is not provided) no-load
   4) Amps
   5) Full-flow amps
   6) No-flow amps
   7) Inlet temperature to each pump under normal operating conditions

2. Heat Exchangers, Water Heaters and Mixing Valves:
   a. Installation Data
      1) Manufacturer, model, and type
      2) Flow rate
      3) Inlet (entering) and outlet (leaving) temperatures
      4) Inlet (entering) and outlet (leaving) pressures
   b. Recorded Data
      1) Flow rate
      2) Entering and leaving water temperatures
      3) Entering and leaving pressures
3. Domestic Water Service
   a. Recorded Data
      1) Incoming domestic water pressure from the serving utility upstream of all building pressure regulating valves with time and date
      2) Incoming domestic water temperature with time and date

3.4 HEAT EXCHANGER CAPACITY VERIFICATION

A. Water/water heat exchanger equipment capacity shall be verified by measuring the flow rate and temperature differential of the water.

B. Capacity verification shall be performed after water systems have been balanced.

3.5 TOLERANCES

A. Set domestic hot water flow rates within plus or minus 10 percent of specified flow rates.

3.6 CERTIFIED REPORTS

A. Submittals: Six (6) copies of the reports described herein final inspection.

B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be included.

C. Reports: Reports shall conspicuously identify items not conforming to contract requirements, or obvious malfunction and design deficiencies.

D. Certification: Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

END OF SECTION 220593

SECTION 220700

PLUMBING INSULATION

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:
   1. Piping Services:
      a. Domestic hot water supply and return.
      b. Domestic cold water, unless otherwise noted on drawings.
      c. Irrigation water, unless otherwise noted on drawings.
      d. Roof and overflow roof drain piping and drain bodies. (See Drains below)
      e. Sanitary vent piping in unheated spaces.
      f. Drains from electric water coolers to first connection.
      g. All heat traced piping.
      h. All valves, separators, strainers and fittings for systems listed above.
   2. Roof Drains and Associated Piping: All roof and overflow drain bodies and associated piping are to be insulated except in Hot-dry and Mixed-Dry climate zones as defined by the National Renewable Energy Laboratory Building America zone map. See Pacific Northwest National Laboratory publication PNNL 17211, Guide to Determining Climate Regions by County.
   3. Types of plumbing piping insulation specified in this Section include the following:
      a. Pipe insulation: Fiberglass.
      b. Pipe insulation: Flexible elastomeric closed cell foam.
   4. Insulation jackets:
      a. Interior application
      b. Exterior application
      c. Removable covers
   5. Insulation accessories.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods.

1.3 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room, typically between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 34°F (1°C), as stated in ASHRAE Fundamentals under 99% column for winter design conditions.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
a. B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plat.
b. C165 - Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
c. C167 - Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations.
d. C177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission.
e. Properties by Means of the Guarded-Hot-Plate Apparatus.
f. C195 - Specification for Mineral Fiber Thermal Insulating Cement.
g. C196 - Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
h. C302 - Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
i. C303 - Test Method for Density of Preformed Block-Type Thermal Insulation.
j. C305 - Test for Thermal Conductivity of Pipe Insulation.
k. C356 - Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
l. C423 – Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
m. C449 - Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
n. C518 – Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
o. C534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
p. C547 - Specification for Mineral Fiber Preformed Pipe Insulation.
q. C552 - Specification for Cellular Glass Block and Pipe Thermal Insulation.
r. C553 - Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).
s. C592 - Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
t. C612 - Specification for Mineral Fiber Block and Board Thermal Insulation.
u. C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
v. C921 - Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
w. C1104 – Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
x. C1071 - Standard Specification for Thermal and Acoustical Insulation.
y. C1338 – Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
z. E84 - Test Method for Surface Burning Characteristics of Building Materials.
aa. E119 - Test for Fire Resistance.
bb. G21 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
cc. G22 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.
2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
a. 90 Energy Conservation in New Building Design.
3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
a. 255 Test Methods, Surface Burning Characteristics of Building Materials.

B. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

C. Products Containing Prohibited Chemicals:
   1. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable:
      a. Pentabrominated diphenyl ether (CAS#32534-81-9)
      b. Octabrominated diphenyl ether (CAS#32536-52-0)
      c. Decabrominated diphenyl ether (CAS#1163-19-50

D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Corrosiveness: Provide insulation such that when tested in accordance with the following test, the steel plate in contact with the insulation shows no greater corrosion than sterile cotton in contact with a steel plate for comparison.
   1. Test Specimen: Two specimens shall be used, each measuring 1” by 4” by approximately 1/2” thick.
   2. Apparatus: Provide a humidity test chamber in which two polished-steel test plates, 1” wide, 4” long and 0.020” thick, shall be placed. Plates shall be clear finish, cold-rolled strip steel, American quality, quarter hard, temper No. 3, weighing 0.85 lb/sq. ft.
   3. Procedure: The steel test plates shall be rinsed with cp benzol until their surfaces are free from oil and grease and allowed to dry. One piece of cold-rolled steel shall be placed between the two insulation specimens and secured with tape or twine. The test specimen and uncovered plate shall be suspended vertically in an atmosphere having a relative humidity of 95% (plus or minus 3%), and a temperature of 120°F (plus or minus 3°F), for 96 hours, and then be examined for corrosion.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation. Also furnish necessary test data certified by an independent testing laboratory. Submit samples.

B. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9)
   2. Octabrominated diphenyl ether (CAS#32536-52-0)
   3. Decabrominated diphenyl ether (CAS#1163-19-50

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Johns Manville, Owens-Corning, Knauf, Armstrong, Pittsburgh-Corning, Trymer, IIG, CertainTeed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix, or approved equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.2 PIPE INSULATIONS

A. Type PI-A: Glass Fiber: Molded fibrous glass pipe insulation shall comply with the requirements of ASTM C 547 and meet ASTM C 585 for sizes required in the particular system. For all fluid distribution temperatures below 45°F the system shall be of a wicking type.
   1. Fiberglass, Non-Wicking:
      a. Manufacturers:
         1) Johns Manville Micro-Lok HP meeting ASTM C547; or FSK faced Micro-Flex (pipe sizes larger than 18")
         2) Knauf
         3) einsulation
      b. Applications: Insulation of piping up to 18" in diameter and 3" thick insulation.
      c. 'K' Value: 0.23 at 75°F.
      d. Maximum Service Temperature: 850°F.
      e. Vapor Retarder Jacket: AP-T PLUS white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, secure with self sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples or vapor barrier mastic as needed.

B. Type PI-B: Flexible Elastomeric Closed Cell Thermal Insulation: Armacel AP Armaflex, Rubatex K-Flex ECO, Aeroflex Aerocel, closed-cell, halogen free, elastomeric insulation. Comply with ASTM-C177, ASTM E 84 and UL 181.
   1. 'K' Value: 0.27 at 75°F.
   2. Density: 3.0 to 6.0 lbs./cu.ft.
   3. Maximum Service Temperature: 260°F.
   4. Seal all seams and joints with contact adhesive.

C. Type PI-C: Cellular Glass- Pittsburgh-Corning Foamglas Meeting ASTM C522: Cellular Glass Thermal Insulation:
   1. 'K' Value: 0.35 at 75°F.
   2. Density: 8.0 lbs./cu. ft.
   3. Maximum Service Temperature: 900°F.
   4. Provide with Pittsburg Corning Pittwrap jacketing.

D. Field Applied Jackets (For Interior Applications):
   1. All longitudinal seams shall be located on bottom of pipes.
   2. PVC Plastic: Johns Manville Zeston 2000. One piece molded type fitting covers and jacketing material, gloss white. Connect with tacks and pressure sensitive color matching vinyl tape.
   3. Canvas Jacket: UL listed fabric, 6 oz/sq. yd. plain weave cotton, treated with dilute fire retardant lagging adhesive.
   4. Aluminum Jacket: 0.016" thick sheet, [smooth/embossed] finish, with longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner.
   5. Secure aluminum jackets with 3/8" or ½" stainless steel bands on 12" centers.

E. Field Applied Jackets (For Exterior Applications):
   1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.

2. Aluminum Jacket: 0.016" (minimum) thick sheet, [smooth/embossed] finish, with longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner.
3. Stainless Steel Jacket: Type 304 stainless steel, 0.010" minimum (smooth/corrugated) finish.
4. Secure stainless steel or aluminum jackets with ⅜" or ½" stainless steel bands on 12" centers.
5. Manufacturers: Pabco, Childers, RPR, or approved equal.

F. Removable Covers:
1. Provide removable covers on pumps, backflow devices, valves greater than 2", flanges, strainers, etc., where periodic maintenance or removal of insulation is required.
2. Use of pre-molded fittings with PVC covers is acceptable, unless noted otherwise.
   a. Cold systems: Provide PVC covers on elbows.
   b. Cold systems: Provide Armaflex elastomeric foam for flanges, valves, pumps and strainers.
   c. Hot systems: provide PVC covers on elbows and flanges.
   d. Hot Systems: provide removable blanket covers on valves, pumps, and strainers.
3. Removable- type silicon cloth fiberglass filled insulating blankets:
   a. Mfg: Fit Tight Covers, GLT products, or equal custom fabrication by Insulation Contractor, 0-350°F service operating temperature:
      1) Jacket: silicon impregnated fiberglass cloth
      2) Liner: silicon impregnated fiberglass cloth
      3) Liner reinforcement: stainless steel mesh cloth
      4) Insulation: 1" type E glass matt
      5) Fastening: 2" nomex Velcro
      6) Fastening: 1" straps and stainless steel D-rings
      7) Fastening: 12 gage stainless steel hooks and stainless steel wire
      8) Thread: Kevlar/stainless steel thread

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that piping has been tested for leakage in accordance with specifications before applying insulation materials. All piping shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.2 INSTALLATION

A. General:
1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
2. Remove and replace any insulation that has become wet or damaged during the construction process.
3. Continue insulation and vapor barrier at penetrations and supports, except where prohibited by code.

B. Piping Insulation:
1. Locate insulation and cover seams in least visible locations unless otherwise specified.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Provide insulated dual temperature pipes and cold pipes conveying fluids below ambient temperature with vapor retardant jackets with self sealing laps. Insulate complete system. No staples shall be used on pipes conveying fluids below ambient temperatures (cold systems).

4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
5. Provide insert between support shield and piping on piping 1-1/2” diameter or larger. Fabricate of Johns Manville Thermo-12, or other heavy density insulating material suitable for temperature. Insulation inserts shall not be less than the following lengths:
   a. 1-1/2" to 2-1/2" pipe size 10" long
   b. 3" to 6" pipe size 12" long
6. Use of metal saddles is acceptable as specified in Section 220500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
7. Use of pipe hangers designed as an insulation coupling is acceptable in lieu of saddles and other devices. Klo-Shure coupling or equal.
8. For pipe exposed in mechanical equipment rooms or in finished spaces below 7 feet above finished floor, finish with Johns Manville Zeston 2000 PVC jacket and fitting covers.
   a. Where pumps, valves, strainers, etc., with insulation require periodic opening for maintenance, repair, or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
   b. Cold systems: Provide Armaflex elastomeric foam for pumps and strainers.
9. For exterior applications:
   a. Provide weather protection jacket. Insulated pipe lengths, pumps, fittings, joints, and valves shall be covered with aluminum jacket or stainless steel jacket. Jacket seams shall be located on bottom side of horizontal piping. All lateral joints shall be caulked with a minimum 20-year silicone sealant (clear). All longitudinal joints, except those at the bottom of a horizontal pipe run, shall be caulked with a minimum 20-year silicone sealant (clear).
   b. Apply weather-resistant protective finish such as WB Armaflex to flexible elastomeric insulation. Insulation seams shall be located on the bottom side of horizontal piping. All lateral and longitudinal joints to be sealed with low V.O.C., UV inhibitive adhesive, such as Armaflex 520 BLV adhesive.
10. For underground installations, install per manufacturer's written instructions and recommendations.
11. When maintenance or service access for equipment will result in foot traffic over floor mounted insulated piping the contractor is to fabricate a permanent removable walkway to prevent damage to the piping and insulation.

3.3 PIPING INSULATION SCHEDULE

A. All insulation thicknesses shall meet or exceed State Energy Code requirements as noted below. Increase thickness 1/2” if exposed to exterior ambient air. Minimum thermal resistance in range of 4.2 to 4.6 per inch of thickness. Insulation thicknesses are based on fiberglass insulation and may be adjusted for equivalent insulation values for materials with superior “K” factors.

B. Insulation

SERVICE	PIPE SIZE (inches)	THICKNESS (inches)	REMARKS/MATERIAL OPTIONS
Domestic, hot water	Up to 2 2-1/2 and over	1 1-1/2	Type PI-A,B
Domestic cold water	All Sizes	1	Type PI-A,B
Roof and overflow roof drainage	Up to 2 2-1/2 and over	1 1	Type PI-A,B, within 20 linear ft of drain body
Roof and overflow drain bodies	All sizes	1	Type PI-B
Heat-Traced liquid containing piping exposed to freezing	All Sizes	1-1/2	Type PI-A,B. Provide aluminum jacket and label “heat traced” along with service designator label
Plumbing vents within 10 feet of the exterior in freezing climates	All Sizes	1	Type PI-A,B
PEX domestic hot and cold water	All Sizes	1/2	Type PI-A,B. To meet ASTM E-84, required only where PEX tubing is installed exposed in a ceiling air plenum and tubes are within 18” of another tube.

C. Domestic Cold Insulation (Building Interior): For domestic cold water piping, not already insulated subject to freezing and which is located within the conditioned interior of the building and located in a humid climate, shall be insulated for the first 100 feet of piping with 1/2” (minimum) fiberglass insulation or elastomeric foam. Exposed cold water piping in restaurants and kitchen areas shall also be insulated to prevent condensation.TABLE 2: CODE MINIMUM PIPING INSULATION THICKNESS BASED ON FLUID TEMPERATURE AND PIPING SIZE.

Insulation Based on Washington WSEC Energy Code Table 14-6 Minimum Pipe Insulation Thicknesses or Greater								
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)					
			Runouts up to 2	1 and less	1 - 1-1/2	1-1/2 - 3	4 - 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)					
Space heating systems (steam, steam condensate and hot water)								
105-140	0.22-0.28	100	1.0	1.0	1.0	1.5	1.5	1.5

END OF SECTION 220700

SECTION 22 10 00

PLUMBING PIPING, VALVES AND SPECIALTIES

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to the following:
   1. Pipe and Fittings
      a. Sanitary waste and vent
      b. Storm drain and overflow
      c. Potable Cold water
      d. Potable Hot water
   2. Valves
      a. Water valves
      b. Backwater valves
      c. Backflow prevention valves
      d. Pressure reducing valves
   3. Water meters
   4. Thermometers and gauges
   5. Piping specialties
   6. Pipe escutcheons
   7. Strainers
   8. Drip pans
   9. Air vent
   10. Dielectric unions
   11. Unions
   12. Flanges
   13. Pipe sleeves
   14. Sleeve seals
   15. Valve boxes
   16. Pipe coating

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 223000: Plumbing Equipment

C. Section 224000: Plumbing Fixtures

D. Division 26: Electrical

E. Division 09: Finishes/Painting

1.3 QUALITY ASSURANCE

A. Manufacturers Qualifications:
   1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
   2. Replacement parts shall be readily available and stocked in the USA.

B. Codes and Standards:
   1. All work shall be in full accordance with all applicable codes, ordinances and code rulings.

2. The Contractor shall furnish without any extra charge the labor and material required for compliance of codes.
3. Perform all tests required by governing authorities and as required under all Division 22 Sections. Provide written reports on all tests.
4. Electrical devices and wiring shall confirm to the latest standards of NEC; all devices shall be UL listed and so identified.
5. All plumbing work shall comply with the Americans with Disabilities Act (ADA).
6. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.
7. Provide thermostatic mixing valves and fixtures conforming to ASSE 1070 to limit the maximum water temperature to 110°F for all public lavatories and 120°F for all other public fixtures served with hot water. Handle position stops and temperature mixing valves shall be used as required to limit maximum temperature to prevent scalding. Water heater thermostats shall not be considered a suitable control.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for all piping, valves and specialties indicating dimensions, valve CV, tolerances etc.

B. Shop Drawings: Submit shop drawings indicating underground piping installation showing all fittings with inverts. Indicate all footings and grade beams.

C. Maintenance Data: Submit maintenance instructions on accordance with requirements of Division 01.

1.5 WARRANTY – ADDITIONAL REQUIREMENTS

A. Refer to section 220500 for basic warranty requirements.

B. Provide the additional extended warranty requirements that apply to all plastic piping systems with all types of joints and fittings.
   1. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.
   2. Contractor and Manufacturer warrant that, for a period of twenty five (25) years from the date of Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), the tubing will conform to the requirements of the Contract Documents and will be free from defects.
   3. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.
   4. In addition to the Contractor's and Manufacturer's obligations set forth above and elsewhere, if, within two (2) years after the date of the Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), any part of the system is found to be defective or not in accordance with the requirements of the Contract Documents, the Contractor or Manufacturer, or both, shall correct it at their own expense promptly after receipt of written notice from the Owner to do so.
   5. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.
   1. All pipe, pipe fittings and valves shall be manufactured in North America. Alternatives may be acceptable, but must be submitted and approved by the Owner's Representative prior to bidding.

B. Type M copper piping is not acceptable for any pressure water piping unless specifically noted otherwise.

C. For all Grade B piping specified below grade provide a mill report with production identification numbers for piping submitted to permit tracking of pipe by mill and production lot.

D. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturer's names used herein, unless specifically noted that substitutes are not allowed.

2.2 STANDARD PIPE AND FITTING

A. Domestic Water Pipe & Fittings (Below Grade):
   1. Pipe: ASTM B88, Type K hard drawn copper water tube.
   2. Fittings: Domestic Only, Elkhart, ASME B16.22, wrought copper, 95%-5% tin-antimony solder joints. Wrap underground piping with Scotch Wrap or Pasco Wrap.

B. Domestic Cold Water Pipe & Fittings (Above Grade):
   1. Pipe: ASTM B88, Type L, hard drawn copper water tube.
   2. Fittings: ASME B16.22, wrought copper, 95%-5% tin-antimony solder joints.

C. Indirect drains:
   1. Pipe: ASTM B88, Type M, hard drawn copper water tube.
   2. Fittings: ASME B16.22, wrought copper.
   3. Joints: Lead-free solder joints. Solder shall be lead-free nickel/silver bearing solder meeting ASTM B-32, ASTM B-828. Flux shall be water soluble and shall meet CDA standard test method 1.0 and ASTM B813-91.
   4. Insulate condensate drain pipes with minimum 1/2" insulation to prevent moisture dripping from pipe.

D. Trap Primer Piping:
   1. Pipe: ASTM B88, Type K, soft drawn copper water tube. PEX tubing may be allowed as an alternate material as approved by the local authority having jurisdiction.
   2. Fittings: No joints below ground. For pipes below grade double wrap with Scotch Wrap #51 or PASCO Wrap, with 50% overlap.

E. Sanitary Sewer, Vent, Rainwater Pipe & Fittings:
   1. Pipe: ASTM A74, ASTM A888 cast iron, bituminous coated, "No-Hub". Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and manufactured by AB&I, Charlotte, Tyler or approved equal. Pipe showing rust or cracks in coating shall be removed and replaced.
   2. Fittings: No-hub, ASTM A888.
   3. Couplings Below Grade: Heavy Duty Type 304 stainless steel couplings conforming to FM 1680 and ASTM C-1540 with heavy-duty shield and neoprene sealing sleeve conforming to ASTM C-564 and CISPI 301. Husky SD-4000, Clamp-All Hi-Torq 125 or Ideal Tridon HD.

4. Couplings Above Grade: Type 301 or 304 stainless steel couplings conforming to FM-1680 and ASTM C1540 with heavy-duty shield and neoprene sealing sleeve conforming to ASTM C-564 and CISPI 301. Husky HD-2000, Clamp-All Hi-Torq 80, Mission HeavyWeight or Ideal Tridon MD.

G. Water Service to Building:
1. Pipe: Class 52 ductile iron, ANSI A21.51, AWWA C1510-70, 150 psi cement lined factory encased with 8 mil polyethylene tube or sheet.
2. Fittings: ANSI A21.10 mechanical joint, AWWA C110-1971, 250 psi. Fittings to be double field wrapped with 2", 20 mil vinyl tape, 50% overlap.
3. All fittings shall be restrained with 2000 psi thrust blocks in accordance with NFPA
4. Fire Protection: Refer to Specification Section 211000.

H. Vent, Pipe & Fittings-ABS Alternative for Buried Piping:
1. Pipe: Charlotte Pipe and Foundry, ASTM F 628, ASTM D 3965, NSF Standard 14, ABS (acrylonitrile-butadiene-styrene) compound with Cell Class 42222. Use in non-pressure applications where operating temperature will not exceed 140ºF.
2. Fittings: ASTM D 2661, ASTM D 2235, ABS DWV Fittings shall be by a single manufacturer and to be installed in accordance with manufacturer's recommendations. Solvent cement joints.

2.3 VALVES: GENERAL

A. General: Valve ratings shall exceed respective system operating pressures by 50% (minimum). All valves shall be line size unless otherwise noted.

B. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing manufacturer's figure number, size, location, and valve features for each required valve.

C. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

D. Acceptable manufacturers (manufacturer and model number listed for individual valves indicates minimum acceptable by all manufacturers):
1. Gate, Ball, Check or Butterfly: Apollo, Hammond, Nibco (commercial grade, US manufacturer only), Milwaukee, Victaulic or Watts.
2. Lubricated Plug Valves: Homestead, Resun, or Rockwell.
3. Backflow Preventors: Apollo, Ames, Febco, Cla-Val, Watts or Wilkins.
4. Pressure Reducing Valves: Apollo, Cash-Acme, Cla-Val, Watts, or Wilkins.
5. Solenoid Valves: ASCO, Automatic or Magnatrol.
6. Circuit Setters: Griswold (Venturi with characterized ball valve only), Wheatley (Y-globe type only), Armstrong, CircuitSolver, or Tour & Anderson.

E. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on the valve body.

F. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, other than plug valves. Provide one wrench for every 10 plug valves, and one in each size. Provide extended levers/stems for valves on insulated lines. For manual valves 2 ½" and larger located 8 feet above the floor in mechanical rooms provide chain operator to permit operating the valve from 4'-0" above floor.

G. Valve Features:
1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.

2. Drain: Comply with MSS SP-45, and provide threaded pipe plugs.
3. Flanged: Valve flanges complying with ASME B16.1 (cast iron), ASME B16.5 (steel), or ASME B16.24 (bronze).
4. Threaded: Valve ends complying with ANSI B2.1.
5. Solder-Joint: Valve ends complying with ASME B16.18.
6. Flangeless: Valve bodies manufactured to fit between flanges complying with ASME B16.1 (cast iron), ASME B16.5 (steel), or ASME B16.24 (bronze).

2.4 DOMESTIC PLUMBING SERVICE VALVES

A. Ball Valves:
1. 2" and Smaller: 600 psi, 2 piece, bronze body, soldered ends for copper pipe and threaded ends for iron pipe, chrome plated brass ball, Teflon seat, brass stem, steel handle, full port, low lead compliant. Apollo Lead Free #77CLF Series or equal.

B. Butterfly Valves:
1. 2-1/2” and Larger: MSS SP-67, lug wafer, ductile iron body, stainless steel disc, stainless steel stem, EPDM seat, low lead compliant, memory stop control, lever handle thru 5" size and worm gear operator for 6" and larger. Mount stem in horizontal position. Apollo #LD141/WD141 Series or equal.

C. Check Valves:
1. 2" and Smaller: Class 125, MSS SP-80, ASTM B62 and ASTM B16, cast bronze body, soldered ends for copper pipe, screwed cap, swing type, Teflon bronze disc, low lead compliant. Apollo Lead Free #163LF Series or equal.
2. 2-1/2" and Larger: Class 125, MSS SP-71, ASTM A126 class B cast iron body, bolted bonnet flanged ends, bolted cap, swing type, cast iron disc with bronze face rings, low lead compliant. Apollo Lead Free #910F Series or equal.
3. Vertical or High Flow: Class 125, cast bronze, high-flow body, TFE seat, brass check, low lea compliant, stainless steel guide and spring. Apollo Lead Free #61LF Series or equal

D. Angle Stop Valves:
1. Heavy duty 1/4 turn commercial stop, brass body, chrome plated, 125 psi working pressure, ASME A112.18.1, low lead compliant. Provide with loose key handle in public access spaces for vandal resistance. Chicago Faucets #ST Series, Brasscraft #KT Series, or equal.

2.5 BALANCING VALVES: MAXIMUM 125 PSIG SYSTEM WORKING WATER PRESSURE

A. Pressure Dependent Water Flow:
1. 1/2" and Larger: Construction and attachment style as required by piping system. Ball or globe valve design with memory stop. Valves shall be field adjustable. Install in pipe with minimum length of unrestricted straight pipe equivalent to five pipe diameters upstream and two pipe diameters downstream. Presso #Venturi B-Plus series, Armstrong, Tour & Anderson, or equal.

2.6 BACKFLOW PREVENTION VALVES

A. General: All backflow prevention valves shall be State approved and listed.

B. Reduced Pressure Principal Backflow Prevention Assembly for High Hazard Applications:
1. 2" and Smaller: Assembly shall consist of shutoff ball valves in inlet and outlet, and strainer on inlet. Assemblies shall include test cocks and pressure-differential relief valve located between two positive seating check valves and shall comply with requirements of ASSE Standard 1013 and AWWA C506. Bronze construction, threaded ends, stainless steel internal parts, and air gap fitting. Route pipe from air gap fitting to approved waste receptor. Apollo Lead Free #RP4ALF Series valve with #AGD4A air gap fitting.

2. 2-1/2" and Larger: Assembly shall consist of shutoff OS&Y gate valves in inlet and outlet, and strainer on inlet. Assemblies shall include test cocks and pressure-differential relief valve located between two positive seating check valves and shall comply with requirements of ASSE Standard 1015 and AWWA C506. Stainless Steel body construction, flanged ends, center stem guided check valves, and air gap fitting. Route pipe from air gap fitting to approved waste receptor. Apollo Lead Free #RP4ALF-OS&Y valve with #AGD4A air gap fitting or equal.

C. Double Check Valve for Low Hazard Applications:
1. 2" and Smaller: Assembly shall consist of shutoff ball valves in inlet and outlet, and strainer on inlet. Assemblies shall include test cocks and two positive seating check valves and shall comply with requirements of ASSE Standard 1015 and AWWA C510. Bronze construction, threaded ends, and stainless steel internal parts. Apollo Lead Free #DC4ALF Series or equal.
2. 2-1/2" and Larger: Assembly shall consist of shutoff OS&Y gate valves in inlet and outlet, and strainer on inlet. Assemblies shall include test cocks and two positive seating check valves and shall comply with requirements of ASSE Standard 1015 and AWWA C506. Epoxy coated cast iron body construction, flanged ends, and stainless steel internal parts. Apollo Lead Free #DC4ALF Series or equal.

D. Atmospheric Vacuum Breaker: Assembly shall consist of a bronze vacuum breaker body with silicone disc, and full size orifice. Device shall be IAPMO listed, meet ASSE 1001 and ANSI A113.1.1. Chrome plated in finish areas. Apollo Lead Free 38LF Series.

E. Pressure Vacuum Breaker: Assembly shall consist of a one piece bronze or stainless steel body, with stainless steel spring loaded check, rubber diaphragm, and atmospheric vent, breakaway set screw. Provide chrome plated in finish areas. Apollo #4A-PVB Series or equal.

2.7 PRESSURE RELIEF VALVES

A. Pressure Relief Valve: Lead free bronze body construction, thermostat and test lever, and initial pressure relief set at 125 psi (adjust for system requirements). Certified to meet ASME low pressure heating boiler code.

B. Manufacturers: Watts #LF3L, Cash Acme #LFF-95 Series or equal.

2.8 TEMPERATURE AND PRESSURE RELIEF VALVES

A. Temperature and Pressure Relief Valve: Lead free bronze body construction, thermostat and test lever, temperature relief set at 210^0F, and pressure relief set at 125 psi. Certified to meet ASME low pressure heating boiler code and ANSI Z21.22.

B. Manufacturers: Watts #LF Series (100XL, 40, 140, N240, 340), Cash Acme #FVX Series or equal.

2.9 VACUUM RELIEF VALVES

A. Vacuum Relief Valve: Lead free brass body construction, protective cap, 1/2” male NPT, maximum operating temperature 250^0F. Tested and rated to ANSI Z21.22.

B. Manufacturers: Watts #LFN36 Series, Cash Acme #VR-801, or equal.

2.10 THERMOMETERS AND GAUGES

A. General:
1. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.
2. No mercury shall be used in thermometers due to hazardous material classification.
3. Acceptable Manufacturers: Weksler, Winters, Trerice, Marshalltown or US Gauge.

B. Thermometer Test Wells:
1. Provide thermometer test wells as indicated, constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

C. Temperature Gauge Connector Plugs:
1. Provide temperature gauge connector plugs pressure rated for 500 psi and 200°F (93°C). Construct of brass and finish in nickel-plate, equip with 1/2" NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" OD probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

D. Pressure Gauges:
1. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Type: General use, 1% accuracy ANSI B40.1 grade A, phosphor bronze bourbon type, bottom connection.
3. Case: Drawn steel or brass, glass lens, 4-1/2" diameter.
4. Connector: Brass with ¼" male NPT.
5. Scale: White coated aluminum, with permanently etched markings.
6. Pressure differential range shall be 100 psig minimum for the appropriate application with maximum 1 psig divisions.

E. Pressure Gauge Cocks:
1. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Gauge cock constructed of brass with 1/4" female NPT on each end, and "T" handle brass plug.
2. Syphon: 1/4" straight coil constructed of brass tubing with 1/4" male NPT on each end.
3. Snubber: 1/4" brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

F. Pressure Gauge Connector Test Plugs:
1. Provide pressure gauge connector plugs pressure rated for 500 psi and 200°F (93°C). Constructed of brass and finish in nickel-plate, equip with 1/2" NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8" O.D. probe assembly from dial type insertion pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

2.11 PIPING SPECIALTIES

A. General:
1. Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or provide proper selection to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is installer's option.

B. Pipe Escutcheons:
1. Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime zinc base paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide stainless steel, cast brass or sheet brass escutcheons, solid or split hinged.

3. Pipe Escutcheons for Dry Areas: Provide stainless steel escutcheons, solid or split hinged.

C. Low Pressure Y-Type Pipeline Strainers:
1. Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125% of the working pressure of piping system, with Type 304 stainless steel screens, with 3/64" perforations at 233 0.045" perforations per square inch.
2. Threaded ends, 2" and smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with hose bibb. Sarco, Wheatley or Mueller.
3. Flanged ends, 2-1/2" and larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with hose bibb. Sarco, Wheatley or Mueller.
4. Grooved ends 2 ½ and larger: Ductile iron body, bolted screen retainer with off center blowdown fitted with hose bibb. Victaulic or Gustin-Bacon.

D. Drip Pans:
1. Provide drip pans fabricated from 16-gauge galvanized sheet metal with watertight joints, and with edges turned up 2-1/2". Reinforce top by structural angles. Provide hole, gasket, and flange at low point for watertight joint and 1" copper drain line connection. Extend 1” drain to nearest approved receptor.

E. Air Vent with Valves:
1. Cold water and hot water vent valve with 1/4 turn ball shut-off valve. Tapped at top for 1/8” or 1/4” NPT drain connection. Removable top and built-in check valve. Maximum operating pressure 75 psi. Maximum operating temperature 250ºF. Hoffman #79, Dole #75 or equal.

F. Dielectric Unions:
1. Provide standard products recommended by manufacturer for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.

G. Dielectric Flanges: Provide dielectric flanges for flanged transitions between dissimilar metal piping. Watts Series 3100 or approved equal.

H. Unions:
1. Unions shall be of type specified in following schedule:
   a. Black Steel, 2" and smaller: 250 lb. screwed malleable iron, ground joint, brass to iron seat.
   b. Black Steel, 2-1/2" and larger: 150 lb. cast iron screwed flanged, flat faced, full faced gasket.
   c. Soldered Copper or Brass Pipe, 2" and smaller: 150 lb. cast bronze or copper, ground joint, non-ferrous seat with soldered ends.
   d. Screwed Copper or Brass Pipe, 2" and smaller: 150 lb. cast brass, ground joint, brass to brass seat, with threaded ends.
   e. Flanged Copper or Brass Pipe, 2-1/2" and larger: two (2) 150 lb. cast bronze flanges.
   f. Manufacturer: EPCO, Mueller, Stanley G. Flagg or Watts.

I. Flanges:
1. Provide flanges at flanged connections to equipment, tanks and valves. Faces of flanges being connected shall be alike in all cases. Connection of raised-face flange to flat-faced flange not permitted.
2. Use ASTM A307, Grade B, bolts and nuts for cast iron flanges and ASTM A193 for steel flanges. Regular square head unfinished bolts with heavy semi-finished hex nuts ASTM A194. Cadmium plated where exposed to weather. Rating: 150 lb. or 300 lb. in high pressure portions.
3. Type of pipe and corresponding flanges as follows:
   a. Screwed Black Steel Pipelines: 125 lb. black cast iron screwed flange, flat faces.
   b. Welded Steel Pipe, 150 lb. black forges steel welding flanges, 1/16" raised fact ASTM A181 Grade I. Use flat face when connected to flat faced companion flange.

J. Pipe Sleeves:
   1. Provide fire proof sleeve assemblies utilizing UL rated sealant systems at all fire rated penetrations. For non-rated sleeve penetrations pack the annular space between the pipe and sleeve with fiberglass and/or mastic.
   2. Sleeves shall provide a minimum 1/2" annular clearance around pipe.
   3. Sheet metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3" and smaller, 20 gauge; 4" to 6", 16 gauge; over 6", 14 gauge.
   4. Steel pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
   5. Iron pipe: Fabricate from cast iron or ductile-iron pipe; remove burrs.
   6. Plastic and copper pipe: Fabricate from Schedule 80 PVC plastic pipe; remove burrs.
   7. Sleeves through interior concrete walls and floors: Telescopic, submerged, adjustable sleeves by Adjust-to-Crete, AMI or Shamrock. Floor sleeves to extend a minimum of 1” above finished floor.
   8. Through exterior walls and floor on grade: 150-pound class cast-iron pipe sleeve. Where waterproof membranes are used, provide membrane clamps. For insulated piping, sleeve diameter shall not be less than diameter of insulated pipe.
   9. Cast-in-place watertight device for protecting penetrating objects from expansion and contraction of concrete. Factory-assembled for use in cast-in-place concrete floors and walls and consisting of two outer sleeves and a one-piece radial extended-flange waterstop gasket, with mid-body seal for embedment and sealing to concrete slab and continuous water seal extending to the penetrating pipe.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/HOLDRITE, Hydro Preseal, or equal.
      b. Outer Sleeves: EPDM attached to the mid-body seal forming an area with which to attach the device to the structural reinforcing rod determining the position of sleeve in the wall.
      c. Water Stop Mid-body Seal: Flexible polymer seal with radial extended flange consisting of one to three concentric raised rings which lock into concrete, maintaining seal over time as concrete contracts from sleeve.

K. Sleeve Seals:
   1. All sleeves shall be sealed to prevent intrusion of moisture, dust or insects.
   2. Underground: For sleeves passing through exterior or foundation walls, provide mechanical link seal assembly.
   3. Aboveground: For sleeves passing through walls or floors provide a non-toxic 3-hour rated fire resistant silicone foam sealant with a Flame Spread Rating of 20. Sealant to be tested and approved under UL 263, ASTM E119, and NFPA 251 Standards. All fire rated penetrations shall be sealed with approved UL System.
   4. Local Approvals: All seals to be provided shall be in accordance with the regulations of all governing agencies of the city, county, and State Fire Marshal's Office.

L. Watertight Sleeve-Seal Systems
   1. Wood Decking Description: Cast-in-place, factory-assembled, one-piece watertight firestop device for use in concrete floors formed with wood decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke, fire, and hot gasses.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/HOLDRITE, Hydroflame Sleeve, or equal.
      b. Consists of an outer sleeve lined with an intumescent strip, and a radial extended flange attached to one end of the sleeve for fastening to concrete formwork.
      c. Include a waterstop gasket and mid-body seal consisting of one to three concentric raised rings for embedment and sealing to the concrete slab.
      d. Provide one-hour, two-hour and/or three-hour fire-resistance rated assemblies as required and tested according to ASTM E 814 or ANSI/UL 1479.

2. Concrete Description: Cast-in-place, watertight tub box drain block out firestop device for use in floors formed with wood decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke and fire, and hot gasses.
   a. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/HOLDRITE, Hydroflame Tub Box, or equal.
   b. Consists of a reinforced polymer box containing a 2-1/2-inches (63.5 mm) thick polystyrene foam insert with an upper water seal consisting of absorbent material and a pitched water trough.
   c. Include a sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork.
   d. Include two support legs each with a radial extended flange for balance and for fastening to concrete formwork, and a lower water-seal and radial extended flange attached to the lower end of the sleeve for fastening to concrete formwork and a waterstop gasket with three concentric raised rings for embedment and sealing to the concrete slab.
   e. Provide one-hour, two-hour and/or three-hour fire-resistance rated assemblies as required and tested according to ASTM E 814 or ANSI/UL 1479.

M. Valve Boxes: Concrete body, cast iron cover with vandal resistant screws, extensions as required to extend full depth to valve. Valve box cover lettering shall correspond to the valve service, "Water", "Gas", "Fire", "Sewer", etc. Christy #G8 or equal.

2.12 PIPE COATING

A. Pipe coatings and or wrapping may be required for certain pipe materials where pipes are located in corrosive soils or corrosive air environments. Verify local soil and air conditions with building department and soils report, when available. Protect all underground buried steel and copper pipe and fittings. Protect all aboveground exposed steel and copper pipe and fittings located in corrosive air environments. Buried cast iron does not require protection unless specifically required by the AHJ or project Soils Report.Provide pipe protection using one of the following methods:
   1. Twice Wrap 20 Mil. Scotch Wrap PVC No. 51, 50% overlap.
   2. Prefabricated extruded plastic cover with joints sealed with two coats of 20 Mil. Scotch Wrap No. 51 or Pasco Wrap 20 mil weight.

B. Furnish corrugated stainless steel tubing (CSST) with factory-applied corrosion –resistant polyethylene jacket for use in corrosive atmosphere. Coating properties include the following:
   1. Gastite corrugated stainless steel tube jacket shall be UV-Resistant polyethylene meeting the requirements of ASTM E84 for flame spread and smoke density.

2.13 EXPANSION COMPENSATORS

A. General: Pipe expansion, in general, is to be absorbed in bends, swing joints, expansion loops, and offsets. All piping mains, branches and runouts shall be installed to allow for free expansion and contraction without developing leaks or undue stressing of pipe. Stresses shall be within allowable limits of ASME B31.1 for pressure piping. Vertical piping for domestic hot water, chilled water, heating water, steam and steam condensate shall be provided with expansion joints at each floor. Expansion products to conform to the standards of the Expansion Joint Manufacturer's Association. Expansion joints shall not required packing. Installer shall select materials and pressure/temperature ratings to suit intended service. Select packless expansion joints to provide 150% absorption capacity of calculated maximum piping expansion between anchors. All connections shall have ends to match piping system application.

B. Expansion Compensators (Pipe Compression and Extension): Multiple stainless steel bellows and stainless steel liner with shroud and end fittings. Keflex #311 series or approved equal.

C. Flexible Expansion Joint/Seismic Connector for Steel Pipe: Stainless steel hose and braid, 180° return, CSA approved, and end fittings. Metraflex #Metraloop or approved equal.

D. Flexible Connection for Steel Pipe (Piping and Equipment Located Outside the Building): Stainless steel hose and braid, with threaded or flanged ends. Metraflex #SST or approved equal.

E. Flexible Connection for Copper Pipe: Bronze hose and braid, copper tube ends. Metraflex #BBS or approved equal.
   1. For non-critical pump connections. Furnish with fluorelastomer tube and cover to ASTM D2000 Grade 1HK710. The body shall be reinforced with rectangular body rings and six bias plies of fiberglass/kevlar fabric rated 190#/26" vacuum at 250°F. Provide galvanized flat (not L shaped) back up rings and control rods to limit maximum axial extension. Garlock #206 EZ-FLO or approved equal.
   2. Flexible Ball Pipe Joints: Provide flexible ball pipe joints where indicated for piping systems, with materials and pressure/temperature ratings selected by installer to suit intended service. Design joints for 360° rotation, and with minimum of 50° angular flexing movement for sizes 1/4" to 4". Provide two composition gaskets for each joint. Barco or approved equal.

F. Pipe Alignment Guides: Provide pipe alignment guides on both sides of expansion joints, and elsewhere as indicated on drawings. Guide shall be of carbon steel construction with split guiding cylinder and integral anchor base and internal four finger two-piece spider. Cylinder wall thickness shall be equal to schedule 40 wall thickness of pipe being guided. Spider shall be capable of clamping directly to pipe and moving only in an axial direction while inside cylinder. Anchoring directly to building substrate. Metraflex #Style IV or equal.

G. Expansion Loops: Provide field fabricated pipe expansion loops as detailed on the drawings or in place of mechanical expansion joints.

PART 3 - EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work unless so indicated on Drawings or approved by Architect or Owner’s Representative.

3.2 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.3 INSTALLATION

A. Coordinate the work between the various Plumbing Sections and with the work specified under other Divisions of the work or contracts toward rapid completion of the entire project. If any cooperative work must be altered due to lack of proper supervision or failure to make proper provisions in time, then the work hereunder shall include all expenses of such changes as are necessary in the work under other contracts, and such changes shall be directly supervised by and made to the satisfaction of the Owner’s Representative.

B. The cooperative work not included in the Plumbing Division related to the general construction work is as follows:
   1. All formed concrete work.

2. Framed openings in masonry and other Architectural and Structural elements.
3. Wood grounds and nailing strips in masonry and concrete.
4. Sloping of floors to drains and floor sinks.
5. Sloping of roof-to-roof drains and overflow drains.

C. Inspect all material, equipment, and apparatus upon delivery and do not install any that may be subject to rejection as a result of damage or other defects. Provide tarps and visqueen cover to protect equipment and piping delivered to and stored at the site.

D. Installation of backflow prevention devices mounted more than 5 feet above the floor shall be provided with a permanent platform capable of supporting a tester or maintenance person.

3.4 WORKING PRESSURES

A. All fittings, valves, pipe, specialties equipment shall be rated for the working pressure subjected in the installed locations.

B. Drawings indicate working pressure in each system. The rating of the equipment and material shall not be less than that of the system pressures.

3.5 PIPES SIZES TO EQUIPMENT

A. General: Pipe sizes indicated shall be carried full size to equipment served. Any change of size to match equipment connection shall be made within one foot of equipment.

B. At temperature control valves with sizes smaller than connected lines, reduction shall be made immediately adjacent to valve.

3.6 PIPING INSTALLATION

A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints or couplings, but with adequate and accessible unions for disassembly and maintenance or replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16" misalignment tolerance. Comply with ASME B31 Code for Pressure Piping.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details, and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" clearance outside insulation. Whenever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as indicated.

C. Where buried piping, such as domestic cold water or natural gas, transitions into a building-on-grade the piping shall not penetrate the slab or perimeter structure and must extend vertically a minimum of 12” above finished floor level before penetrating the exterior perimeter wall.

D. Elevator Machine Rooms, Switchgear, Generator, Telecommunications, Telephone Rooms, and Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces. Route drip pan drain piping to floor drain, floor sink or other approved receptor.

E. CSST tubing, fitting, and strike-protection are to be Gastite® and shall be installed per the current version of the Gastite® Design & Installation Guide and per approval of local Authority Having Jurisdiction. Gastite® supplied training shall be obtained by all installers prior to installation. The gas-piping system shall be pressure tested in accordance with all requirements of local Authority Having Jurisdiction, ANSI LC-1 and the most current edition of the Gastite® Design and Installation Guide.

F. Install air vents, with shutoff valves, in all closed water systems at high points of systems and at any other point necessary to free system of air. A shut-off valve shall be provided in riser to each vent valve to facilitate servicing. A 1/4” or 3/8" type "L" copper tubing drain line shall be run to drain receptor to carry away water that valve discharges. Manual type vent may be used in lieu of automatic type, where specifically shown on the Drawings.

3.7 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) minimum annular clear space between piping and concrete slabs and walls.
   1. When cast-in-place watertight sleeve seals are required, select sleeve size to match the size and type of pipe to be installed.
   2. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2” (50 mm) minimum above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4” (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."
   4. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping." Exception: When fire-resistance-rated cast-in-place watertight sleeve seals are required for floor penetrations, additional firestopping is not necessary.

3.8 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

C. Aboveground, Cast-in-Place Watertight Sleeves. Select sleeve size based on pipe size and material to be inserted, and thickness of wall.
   1. Install cast-in-place watertight sleeves for pipes NPS 6 (DN 150) and smaller in diameter.

2. Position cast-in-place water tight sleeve in wall space securing sleeve to reinforcing steel using tie wire.

D. Underground, Exterior-Wall, Cast-in-Place Watertight Penetrations. Select sleeve size based on pipe size and material to be inserted, and thickness of wall.
1. Install cast-in-place watertight sleeves for pipes NPS 6 (DN 150) and smaller in diameter.
2. Secure sleeve to the reinforcing steel using tie wire.

E. Fire-Resistance Rated, Cast-in-Place Sleeve Installation: Select sleeve size based on size and type of pipe and thickness of the floor. Position and secure sleeve to concrete form using nails or staples. Place concrete, and finish even with top of sleeve.

3.9 WELDING

A. Qualifications of Welders: Welders performing work under this Contract shall be certified and qualified in accordance with tests prescribed by the National Certified Welding Bureau (NCWB) or by other approved test procedures using methodology and procedures covered in the ASME Boiler and Pressure Vessel Code, Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators". Installation shall conform to ANSI 31.1 "Power Piping".
1. Submit for approval the names, identification, and welder's assigned number, letter or symbol of welders assigned to this project.
2. The assigned identification symbol shall be used to identify the work of each welder and shall be indelibly stamped immediately upon completion of each weld.
3. Welders shall be tested and certified for all positions.
4. Submit identifying stenciled test coupons made by each operator.
5. Any or all welders may be required to retake welding certification tests without additional expense.
6. When so requested, a welder shall not be permitted to work as a welder on this project until he has been recertified in accordance with NCWB.
7. Recertification of the welder shall be made after the welder has taken and passed the required tests.
8. Where piping 1-1/2 inches and smaller is butt or socket welded, submit 3 samples of test welds for approval.

3.10 PIPING SYSTEM JOINTS

A. All piping shall be cut squarely, free of rough edges and reamed to full bore. Piping shall be mechanically cleaned prior to make-up of joints and fully inserted into fittings.

B. Provide joints of type indicated in each piping system.

C. Thread pipe in accordance with ANSI B2.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Remove excess cutting oil from piping prior to assembly. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

D. Solder copper tube and fitting joints with lead free nickel/silver bearing solder meeting ASTM. B-32, in accordance with IAPMO IS 3-93, ASTM B-828 and Copper Development Association recommended procedures. Joints shall be cleaned by other than chemical means prior to assembly. "Shock" cooling is prohibited. Fluxes shall be applied liberally to the outside of the pipe and the solder cup of the fitting. Fluxes shall be water soluble for copper and brass potable water applications, and shall meet CDA standard test method 1.0 and ASTM B813-91. Solder shall be applied until a full fillet is present around the joint. Solder and flux shall not be applied in such excessive quantities as to run down interior of pipe. Lead solder or corrosive flux shall not be present at the jobsite.
   1. Manufacturers:
      a. Solder: JW Harris "Bridgit" or Englehard "Silvabrite 100".
      b. Flux: Laco "Flux-Rite 90", MW Dunton "Nokorode CDA Flux", Hercules "Fluid Action Solder Flux".

E. Braze copper tube and fitting socket or extrude joints (T-drill) with BCUP series filler metal without flux. Listed brazing flux shall be used for joining of copper tube to brass or bronze fittings and shall meet AWS FB3A or FB3C. Medical gas system brazing shall be as specified in Section 226313. "Shock" cooling is prohibited. A continuous fillet shall be visible around the completed joint. After cooling, flux residue shall be thoroughly removed with warm water and a brush prior to testing. Do not use BCUP filler on copper alloys containing over 10% nickel.

F. Corrugated stainless steel tube (CSST) fittings joints: Gastite® mechanical tube fittings manufactured from ASTM B16 type 360 brass whose design incorporates a double wall flare for gas-tight seal with Jacket Lock™, mechanical capture of the jacket for enhanced tubing protection.

G. Alternative domestic water piping mechanical press type connections with pre-approval from Owner's Representative. Copper press fittings shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer. Copper press fittings shall conform to the material and sizing requirements of ASME B16.22. O-rings for copper press fittings shall be EPDM. Viega/Ridgid or approved equal.

H. Piping shall be capped during construction to prevent entry of foreign material.

I. Weld pipe joints in accordance with recognized industry practice and as follows:
   1. Weld pipe joints only when ambient temperature is above 0°F.
   2. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
   3. Use pipe clamps or tack-weld joints with 1" long welds, 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" to 20".
   4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and at edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
   5. Do not weld out piping system imperfections by tack-welding procedures. Refabricate to comply with requirements.
   6. At Installer's option, install forged branch-connection fittings whenever branch pipe is indicated, or install regular T-fitting.

J. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

K. Cast-Iron Joints: Comply with coupling manufacturer's Cast Iron Soil Pipe Institute Standards and installation instructions.

3.11 VALVES

A. General: Except as otherwise indicated, comply with the following requirements:
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided as necessary.
   2. Install manual shutoff valves to isolate cold and hot water services to each restroom group. Back-to-back or adjacent men's and women's restrooms are considered a group. Shutoff valves shall be located immediately above or adjacent to the restroom(s) for easy maintenance access.
   3. Install valves, except butterfly valves, with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane without prior written approval. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.
   4. Install butterfly valves with stems mounted horizontally.
   5. All valves mounted higher than 7' above floor in mechanical rooms and where indicated shall be installed with stem horizontal and equipped with chain wheels and chains extending to 6' above floor.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends of types of pipe/tube connections:
   1. Copper Pipe, 2-1/2" and Smaller: Soldered-joint valves.
   2. Steel Pipe, 2" and Smaller: Threaded joint valves.
   3. Larger Pipe Sizes: One of the following, at installer's option:
      a. Flanged valves.
      b. Lug valves.

D. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

F. Fluid Control: Except as otherwise indicated, install gate, ball, plug, circuit setter, globe, and butterfly valves to comply with ASME B31.9.

G. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.

H. Wafer Check: Install between 2 flanges in horizontal or vertical position.

I. Ball Valve: Ball valve used on gas systems shall be UL listed, CSA approved for pressure of system, no exception.

J. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

K. Valve Identification: Tag each valve in accordance with Section 220500.

L. Cleaning: Clean factory-finished surfaces. Repair marred or scratched surfaces with manufacturer's touch-up paint.

3.12 TEMPERATURE GAUGES

A. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor without supplemental illumination. All gages to be installed with snubbers to absorb system shock.

B. Install in the following locations, and elsewhere as indicated:
1. At outlet of hot water heaters.
2. At inlet and outlet of boilers.

3.13 MECHANICAL SLEEVE SEALS

A. Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form a watertight seal.

B. Fire Barrier Penetration Seals: Fill entire opening with sealing compound in compliance approved and listed UL system number. Adhere to manufacturer's installation instructions.

3.14 SUPPORTS AND HANGERS (See 220500-BASIC PLUMBING MATERIALS AND METHODS)

3.15 EQUIPMENT RAILS AND PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed.

C. Verify roof insulation thickness and adjust raise of cant to match.

3.16 VIBRATION CONTROL ISOLATORS

A. Refer to Section 220548 – Vibration Isolation for Plumbing Piping and Equipment.

3.17 EXPANSION LOOPS

A. Expansion Loops: Fabricate expansion loops as indicated, in locations indicated, and elsewhere as determined by installer for adequate expansion of installed piping system. Subject loop to cold spring which will absorb 50% of total expansion between hot and cold conditions. Provide pipe anchors and pipe alignment guides as indicated, and elsewhere as determined by installer to properly anchor piping in relationship to expansion loops.

B. Expansion Compensation for Risers and Terminals: Install connection between piping mains and risers with at least five pipe fittings including tee in main. Install connections between piping risers and terminal units with at least four pipe fittings including tee in riser.

3.18 EXPANSION COMPENSATORS

A. Install as noted on plans. Where plans do not indicate spacing of guides or other pertinent information, install per manufacturer's recommendations.

3.19 EXCAVATION AND BACKFILL

A. Underground piping shall be installed in stable, open trench work. Trench excavations shall be a minimum of 16” wide, true to line and grade. Contractor shall exercise all due shoring and safety procedures. No stones larger than 1” may be present in the trench to a minimum depth of 4” below the trench bottom. The trench shall be free of job site debris, and free of corrosive media. Pipe crown shall be not less than 24” below the finished ground surface for metallic pipe, and 30” for non-metallic pipe, unless otherwise indicated on the drawings or directed by the Architect. Trenches shall be kept

free of excess moisture, and shall be kept open for only a short a time as necessary for installation, testing and inspection. Dispose of surplus excavation and seepage water as directed by the Architect.

B. Piping shall be properly bedded and backfilled over stable trench bottom to a level of at least 12" above the pipe crown with thin layers of unwashed sand, dampened but not puddle, and free of organic or corrosive materials and excessive moisture. Backfill shall be placed in thin layers not to exceed 6" and tamped by mechanical tampers to a minimum 90% Modified Proctor Density, in accordance with ASTM D-1557-58T. Trenches shall be backfilled to a minimum depth of 36" prior to being wheel loaded. Replace to their original condition all turf, plants, concrete, asphalt, or other improvements which constitute landscaping, traffic areas or other improved areas which become disturbed by excavation. In graded and undeveloped areas, in addition to procedures specified above, backfill trenches with crown 8" above the surrounding surface.

C. Excavated and backfill in soils of unstable nature shall be provided as directed by Architect or Owner's Representative.

3.20 PIPE INSPECTIONS

A. It is the intent of the Contract Documents that systems be inspected at completion of each phase while under tests required for administrative authorities, and prior to concealment, i.e. "Rough-in" "top-out" and final.

B. Inspection – Below Grade: All piping installed below grade shall be inspected prior to burial by the Owner's Representative. Contractor must notify Owner's Representative no less than 24 working hours prior to inspection time. Should the piping be buried prior to inspection the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

C. Inspection – Above Grade: All piping installed above grade shall be made available for inspection upon completion and prior to finish of walls and ceilings. Contractor must notify Owner's Representative no less than 24 working hours prior to the desired inspection time. Should the piping be hidden within the structure prior to inspection the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

3.21 CLEANING, FLUSHING, DISINFECTING

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any).

B. Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports, and accessory items.

C. Inspect pressure piping in accordance with procedures of ASME B31.

D. Disinfect water mains and water service piping in accordance with Section 220500.

3.22 TESTING

A. Provide all tests specified hereinafter. All tests shall meet or exceed the minimum requirements of applicable codes and local ordinances. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Architect, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Piping: Remove from the system, during testing, all equipment which would be damaged by test pressure. Replace removed equipment when testing has been accomplished. The system may be tested in sections as the work progresses; however, any previously tested portion shall become a part of any latter test of a composite system. Correct leaks by remaking joints with new material.

C. Test time will be accrued only while full test pressure is on the system, unless indicated otherwise. “Tolerance” shall be no pressure drop, except that due to temperature change in a 24-hour period. Inspect and test all work prior to burying or concealing. Test pressure shall be one and one-half times the system operating pressure or the listed test pressure below, whichever is greater:

System	Test Medium	Test Pressure	Tolerance-Test Period
Domestic Water	Water	150 psig	None – 8 hours
Sanitary Sewer (non-plastic)	Water	10 ft head (or 5 psi air)	No leaks – 8 hours
Vent (non-plastic)	Air	5 psi	No leaks – 8 hours
Sanitary Sewer (plastic)	Water	10 ft head	No leaks – 8 hours
Vent (plastic)	Water	10 ft head	No leaks – 8 hours
Storm	Water	10 ft head (or 5 psi air)	No leaks – 8 hours

D. Valves: Test all valve bonnets for tightness. Test operate all valves at least once from closed-to-open-to-closed position while valve is under test pressure. Test all automatic valves, including solenoid valves, and temperature and pressure relief valves, safety valves, and temperature and pressure relief valves not less than three (3) times.

E. Piping Specialties: Test all thermometers, pressure gauges, and water meters for accurate indication; automatic water feeders, air vents, trap primers, and vacuum breakers for proper performance. Test all air vent points to ensure that all air has been vented.

F. Backflow Preventers: Each testable backflow prevention device shall be tested and approved by certified testers after installation. Submit test results.

END OF SECTION 222000

SECTION 221117

DOMESTIC PEX WATER PIPING

PART 1 - GENERAL

1.1 DEFINITIONS

A. Crosslinked polyethylene, commonly abbreviated PEX, is made from high density polyethylene (HDPE). Crosslinking is accomplished during manufacturing. Crosslinking enhances the physical & mechanical properties of the polymer. The high-temperature properties are improved. Chemical resistance is enhanced by resisting dissolution. Low temperature properties are also improved; its impact and tensile strength, scratch resistance, and resistance to brittle fracture are enhanced. The required degree of crosslinking, according to ASTM Standard F876, is between 70-89%. This specification requires PEX to be designated as PEXa and be manufactured by the high-pressure peroxide method.

1.2 SCOPE

A. This work only applies to piping locating inside residential units, such as hotel rooms, condominium room and apartments. This work is not allowed in commercial areas or work outside residential units.

1.3 SYSTEM DESCRIPTION

A. Domestic potable hot and cold water plumbing system, where shown on the drawings and schedules, shall be crosslinked polyethylene pipe, and shall include the following:
   1. Crosslinked polyethylene (PEXa) piping.
   2. Distribution manifold(s) with balancing and flow control valves where required.
   3. Cold-expansion fittings.
   4. Pipe fasteners as approved by the manufacturer of the PEXa piping.
   5. Supervision and field engineering required for the complete and proper function of the system.

B. Design Requirements
   1. Standard grade hydrostatic pressure ratings from Plastics Pipe Institute in accordance with TR-3. The following three standard-grade hydrostatic ratings are required:
      a. 200°F (93°C) at 80 psi (551 kPa)
      b. 180°F (82°C) at 100 psi (689 kPa)
      c. 73.4°F (23°C) at 160 psi (1102 kPa)
   2. Listing of Flame Spread Index and Smoke Developed Index to ASTM E 84. It may be necessary to encase with 1/2 inch fiberglass insulation or 1/2” Armaflex insulation as required by the manufacturer’s listing.

C. Performance Requirements: To provide a domestic potable hot and cold water plumbing system, which is manufactured, fabricated and installed to comply with regulatory agencies and to maintain performance criteria stated by the PEX pipe manufacturer without defects, damage or failure.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 221000: Plumbing Piping, Valves and Specialties

C. Section 224000: Plumbing Fixtures

D. Division 26: Electrical

1.5 QUALITY ASSURANCE

A. Publications listed here are part of this specification to the extent they are referenced. Where no specific edition of the standard or publication is identified, the current edition shall apply.

B. ASTM - American Society for Testing and Materials
1. ASTM D2765 – Standard Test Method for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics
2. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials
3. ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials
4. ASTM F876 – Standard Specification for Crosslinked Polyethylene (PEX) Tubing
5. ASTM F877 – Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems
6. ASTM F2023 – Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water
7. ASTM F2080 – Standard Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Crosslinked Polyethylene (PEX) Pipe
8. ASTM F1807 – Standard Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing
9. ASTM F2159 – Standard Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing
10. ASTM F2657 – Standard Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing
11. ASTM F1960 – Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Crosslinked Polyethylene (PEX) Tubing
12. ASSE 1061 – Performance Requirements for Push-Fit Fittings

C. AWWA – American Water Works Association
1. AWWA C904-06 - Crosslinked Polyethylene (PEX) Pressure Pipe, 1/2 In.(12 mm) Through 3 In. (76 mm), for Water Service

D. IAPMO – International Association of Plumbing and Mechanical Officials

E. ICC – International Code Council

F. ISO – International Organization for Standardization
1. ISO 9001 – Quality Management Systems – Requirements

G. NSF International
1. NSF/ANSI 14 – Plastic Piping System Components and Related Materials
2. NSF/ANSI 61 – Drinking Water System Components – Health Effects

H. Plastic Pipe Institute
1. PPI TR-3– Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe.

I. Underwriters' Laboratories
1. ANSI/UL 263 – Standard Fire Tests of Building Construction and Materials

J. Plastics Pipe Institute (PPI) Technical Report TR-3 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials

K. Plastics Pipe Institute (PPI) Technical Report TR-4 Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Piping and Fitting Compounds.

L. Manufacturer: Must be a company specializing in the Work of this Section with a minimum of 5 years documented experience.

M. Pipe shall be manufactured in a facility whose quality management system is ISO 9001 certified.

1.6 SUBMITTALS

A. Comply with Division 1, Submittal Procedures. Approval and/or acceptance of all submittals are required prior to fabrication.

B. Product Data: Submit manufacturer's Technical Manual, submittal forms, catalog cuts, brochures, specifications, and installation instructions. Submit data in sufficient detail to indicate compliance with the contract documents.
   1. Submit manufacturer's instructions for installation.
   2. Submit data for equipment, fittings, fasteners and associated items necessary for the installation of the piping and manifolds.

C. Submit computer-generated system design indicating pipe sizing, flow rates and temperatures.

D. Drawings: Provide plans drawn to scale for all installation areas.
   1. Indicate dimensions, descriptions of materials, general construction, component connections, and installation procedures.
   2. Indicate design, schematic layout of system, including equipment and critical dimensions as well as details for protecting exposed PEX piping.

E. Certification:
   1. Submit independent certification results for the piping systems from an accredited independent testing laboratory.
   2. The design shall be approved by a professional appropriately licensed in the jurisdiction where the installation will take place, as being complete and accurate.
   3. Fittings shall be third-party as approved by the manufacturer’s PEX piping system with applicable plumbing and mechanical code certifications.
   4. Fittings encased behind walls or ceilings shall be certified to ASTM F2080.
   5. Samples: Submit samples of metal and exposed finishes if requested by Owner’s Representative.
   6. Maintenance Instructions: Submit instructions for any maintenance required or recommended by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01.

B. Deliver and store piping and equipment in shipping containers with labeling in place. Tubing shall be kept in original shipping boxes until required for installation. Protect all materials from mechanical damage and damage from other trades.

C. Pipe shall be protected from oil, grease, paint, direct sunlight and other elements as recommended by manufacturer.

D. Protect tubing and manifolds from entry of contaminating materials. Install suitable plugs in open tubing and manifold ends until installation.

E. Damaged components shall be removed from the project site and shall not be installed.

1.8 WARRANTY

A. Refer to section 220500 for basic warranty requirements.

B. Provide the following additional extended warranty requirements that apply to all plastic piping systems, including, but not limited to PEX, with all types of joints and fittings
   1. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.
   2. Contractor and Manufacturer warrant that, for a period of twenty five (25) years from the date of Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), the tubing will conform to the requirements of the Contract Documents and will be free from defects.
   3. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.
   4. In addition to the Contractor's and Manufacturer's obligations set forth above and elsewhere, if, within two (2) years after the date of the Certificate of Occupancy (or for such longer period as may be provided under the Contract or law), any part of the system is found to be defective or not in accordance with the requirements of the Contract Documents, the Contractor or Manufacturer, or both, shall correct it at their own expense promptly after receipt of written notice from the Owner to do so.
   5. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Uponor (formerly named Wirsbo)

B. Viega

C. Rehau

D. Approved equal

2.2 COMPONENTS

A. Piping
   1. All pipe shall be high-density crosslinked polyethylene manufactured using the high-pressure peroxide method of crosslinking (PEXa). Pipe shall conform to ASTM F876, ASTM F877 CSA B137.5, NSF/ANSI 14 and NSF/ANSI 61.
   2. Supplier shall provide pipe in sizes 3/8", 1/2", 3/4", 1", 1-1/4", 1-1/2" and 2" in diameter.
   3. Pipe shall be rated for continuous operation of 100 psi gauge pressure at 180°F temperature (690 kPa @ 82°C), and 80 psi gauge pressure at 200°F temperature (550 kPa @ 93°C).
   4. Pipe shall be certified by PPI to standard TR-3, with applicable plumbing and mechanical code certifications.
   5. Pipe to be manufactured using a high-pressure peroxide method with a minimum degree of crosslinking of 70-89% when tested in accordance with ASTM D2765, Method B.
   6. Pipe to be tested for resistance to hot chlorinated water in accordance with ASTM F2023. Pipe to have a minimum extrapolated time-to-failure of 50 years, calculated in accordance with section 13.3 of F2023 and listed as "3306" per the ASTM F876 standard.

7. When required, PEX pipe to have a co-extruded red, white or blue UV Shield made from UV-resistant polyethylene providing a minimum UV resistance of 6 months when tested according to ASTM F2657.
8. Pipe to be manufactured in an ISO 9001 certified production facility.
9. Bend Radius:
   a. The minimum bend radius for cold bending of the pipe shall be not less than five (5) times the outside diameter, or a required by manufacturer.
   b. Bends with a radius less than this shall require the use of a bending template as supplied by the pipe manufacturer, and/or hot air.
10. Pipe to have a Flame Spread Index and a Smoke Developed Index listing to ASTM E84.
11. All fittings shall be located above grade and not concealed in concrete or buried underground.

B. Fitting (Uponor)
1. Fittings shall be manufactured of Engineered Polymer (EP) and shall be supplied by the PEX tubing manufacturer. Lead free brass materials are allowed only for transition fittings. Fitting connections shall be made to the requirements of ASTM F1960. PEX-a cold expansion type fittings shall be an assembly consisting of insert and PEX-a cold expansion ring. Brass Fitting Type: Uponor lead free ProPEX brass fittings.

C. Fittings (Raheu)
1. All Fittings used with crosslinked polyethylene (PEX) water distribution pipe intended for plumbing applications shall be certified to the respective fitting standards. Rehau Everloc brass or stainless steel compression-sleeve fittings.

D. Fittings (Viega)
1. PEX Press fittings shall be manufactured from UNS, C87700, C87710 Bronze, meeting the requirements of ASTM F877 tested as a system with Viega PEX tubing. The PEX Press sleeve shall be manufactured out of a 304 grade or better stainless steel and have three view holes (attached sleeve) to ensure proper PEX tubing insertion. The attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection. The PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

E. Manifolds
1. Material: Distribution manifolds shall be manufactured of copper and be supplied by the piping manufacturer as a proven cataloged part of the manufacturer's system.
2. Copper manifolds shall be manufactured from Type L copper, minimum, or polymer with compression connections as provided by the manufacturer.
3. Copper and/or brass outlets shall be high-temperature brazed (lead-free) into headers or polymer type as provided by the tubing manufacturer.

F. Accessories
1. Tubing Wall Penetration Brackets: Brackets designed for tubing wall membrane penetrations shall be supplied by PEX tubing manufacturer.

G. Markings
1. Pipe shall carry the following markings every three (3) feet (0.9 meters): Manufacturer’s name or trademark, nominal size, PEXa 3306 (material designation) SDR9 (standard dimension ratio), ASTM F876/ F877 / F2080, CSA B137.5, NSF-pw, UPC, 160 psi @ 73.4°F / 100 psi @ 180°F / 80 psi @ 200°F, POTABLE TUBING, manufacturing date and footage mark.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that site is ready to receive tubing, manifold, wiring and controls.

3.2 ACCEPTABLE INSTALLERS

A. As a minimum, installation shall be performed by qualified laborers trained by the manufacturer in the procedures of PEX systems appropriately licensed for the jurisdiction where the installation will take place.

B. Installers must comply with manufacturers technical guidelines, including but not limited to technical manuals, installation guides, technical bulletins and product submittals.

3.3 EXAMINATION

A. Examine areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of work. Do not proceed until unsatisfactory conditions are corrected.

B. Beginning of installation means acceptance of existing conditions.

3.4 PREPARATION

A. Coordinate with related trades and manufacturer's recommendations with regard to installation in conjunction with:
   1. Preparation of space for manifold installation
      a. Prepare a suitable cavity for the manifold, with a secure mounting plate that will secure the manifold at least 30 in (75 cm) above floor level. Manifold must be installed in an area that will allow easy access for piping as well as future access for maintenance.

3.5 INSTALLATION

A. Install in accordance with manufacturer's published installation manual and/or technical guidelines and final drawings. Technical guidelines are the most current and applicable versions of all the technical literature, including but not limited to technical manuals, installation guides, technical bulletins, training presentations and submittals

B. Changes in Direction: PEX tubing shall not exceed an eight times the tubing outside diameter (OD) free bend radius or a five times the tubing OD supported bend radius, with use of a Viega approved bend support. Install fittings for changes in direction where any minimum bend radius is exceeded and branch connections.

C. Manifolds shall be mounted as level as possible.

D. Route piping in an orderly manner, according to layout and spacing shown in final drawings. All installation notes shown on the drawings shall be followed.

E. At connections and fittings, use a plastic pipe cutter to ensure square (90°) and clean cuts, and join pipes immediately or cap ends of pipe to seal from contaminants.

F. Pipe shall be dispensed using a suitable uncoiling device. Remove twists prior to securing pipe. Pipe shall lie flat on an even plane.

G. Piping that passes through expansion joints or walls shall be covered in protective polyethylene convoluted sleeving (flexible conduit) extending 15 in (38 cm) on each side of the joint. Sleeving shall be secured on pipe to prevent movement during installation.

H. Where piping enters or exits a wall a protective conduit shall be placed around the pipe, with the conduit extending a minimum of 6 in (15 cm) into the wall and exiting by a minimum of 6 in (15 cm). For penetrations at manifolds, use rigid PVC bend guides secured in place to prevent movement.

I. PEX Fittings: install fittings and couplings as required by manufacturer's installation instructions using manufacturer specific joining tools.

J. PEX Tubing Protection: Protect PEX tubing from exposure to direct and indirect sunlight exposure. PEX tubing shall be stored under cover, shielded from direct and indirect sunlight when material is stored for any length of time.

K. Penetration Protection: Provide allowance for thermal expansion and contraction of PEX tubing passing through a wall, floor, ceiling or partition by wrapping with pipe insulation, or by installing through an appropriately sized sleeve. Penetrations of fire resistance rated assemblies shall maintain the rating of the assembly.

L. Horizontal Support: PEX tubing must be supported every 32” horizontally with approved suspension clips or plastic insulators.

M. Vertical Support: PEX tubing must be supported at each floor or ceiling penetration and every four feet in between.

3.6 FIELD QUALITY CONTROL

A. Filling, Testing & Balancing: Tests of domestic plumbing systems shall comply with authorities having jurisdiction, and, where required, shall be witnessed by the building official.

B. Pressure gauges used in testing and balancing shall show pressure increments of 1 psig and shall be located at or near the lowest points in the distribution system.

C. Air Testing: In lieu of a water test, the PEX tubing system shall be air tested in accordance with local code after installation, or at least system working pressure, no less than 40 psi and no greater than 100 psi. The test shall be conducted for a period of no less than 15 minutes and no greater than an hour and not leak more than 8 psi over the test duration. Refer to the PEX manufacturers’ installation instructions for safety considerations while conducting air testing. Use soap solution to check for leakage at manifold and fitting connections.

D. Water Testing: The PEX tubing system shall be pressure tested in accordance with local code after installation or to at least minimum system working pressure, no less than 40 psi, and for a period of no less than 15 minutes. Water used for this testing shall come from a potable water source. Test should not exceed pressure rating of PEX tubing and shall have no leaks.

E. Water Test
   1. Purge air from pipes.
   2. Charge the completed, yet unconcealed pipes with water.
   3. Take necessary precautions to prevent water from freezing.
   4. Check the system for leakage, especially at all pipe joints.

F. Perform a preliminary pressure test pressurizing the system to the greater of 1.5 times the maximum operating pressure or 100 psig for 30 minutes.
   1. As the piping expands, restore pressure, first at 10 minutes into the test and again at 20 minutes.
   2. At the end of the 30-minute preliminary test, pressure shall not fall by more than 8 psig from the maximum, and there shall be no leakage.

G. After successfully performing the preliminary pressure test, perform the main pressure test immediately.
   1. The test pressure shall be restored and continued as the main test for 2 hours.
   2. The main test pressure shall not fall more than 3 psig after 2 hours.
   3. No leakage shall be detected.

H. Complete inspection and furnish test reports supplied by the manufacturer of the system.

3.7 CLEANING

A. Clean exposed surfaces upon completion of installation using clean, damp cloth. No cleaning agents are allowed.

B. Comply with manufacturer's recommendations.

C. Disinfection: The PEX hot and cold water distribution system may require system disinfection. When no other method is available, follow the time limitations and exposure levels listed below.
   1. Flush the system with potable water until discolored water does not appear at any of the outlets.
   2. Fill the system with a water chlorine solution containing at least 50 parts per million of chlorine. The system shall be valved in the closed position and to stand for 24 hours. Alternatively, the system shall be filled with water chlorine solution containing at least 200 parts per million of chlorine. The System shall be valved in the closed position and allowed to stand for 3 hours.
   3. Following the standing time, the system shall be flushed with water until the chlorine is purged from the system.

3.8 PROTECTION

A. Protect installation throughout construction process until date of final completion.

B. Replace components that cannot be repaired.

END OF SECTION 221117

SECTION 221123

PUMPS AND SPECIALTIES

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Domestic water booster pump
   2. Expansion tanks - atmospheric.
   3. Expansion tanks - diaphragm type pre-pressurized.
   4. Air separators.
   5. Air elimination valve.
   6. Suction diffusers.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 224000: Plumbing Fixtures

C. Division 26

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products.

B. Codes and Standards: Provide pumps which conform to the requirements of:
   1. Hydraulic Institute (HI): Manufacturer pumps in accordance with "Standards for Centrifugal Rotary and Reciprocating Pumps."
   2. National Electrical Manufacturers Association (NEMA): Provide electrical components which comply with NEMA Standards.
   3. National Fire Protection Association (NFPA):
      a. 70: National electrical Code
   4. Underwriters Laboratories (UL):
      a. UL-778: Motor Operated Water Pumps

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for units showing dimensions, weights (shipping, installed, and operating), capacities, ratings, performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, and installation instructions.
   1. Parallel pump plots: For all parallel and series pump applications submit a combined pump curve showing parallel pump operation and single pump non-overloaded operation verifying that the pump selections operate non-overloading on curve in a single pump operation.
   2. Submittal information to verify all scheduled characteristics are met including efficiency.

B. Shop Drawings: Submit manufacturer's shop drawings indicating dimensions, weight (shipping, operating), required clearances, methods of assembly of components, and location and size of each field connection.

C. Maintenance Data:
1. Submit maintenance instructions, including instructions for lubrication, tube replacement, motor and drive replacement, and spare parts lists.
2. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

D. Wiring Diagrams:
1. Submit manufacturer's ladder-type wiring diagrams for power and control wiring required.
2. Differentiate between factory-installed and field-installed wiring.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products and units against dirt, water, chemical, and mechanical damage. Do not install damaged units - remove from project site.

C. Rigging: Comply with the manufacturer's rigging and installation instructions.

1.6 WARRANTY

A. Provide general one year (12 months) warranty. The warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer to provide factory authorized service.

PART 2 - PRODUCTS

2.1 DOMESTIC WATER VFD BOOSTER PUMP SYSTEM

A. Furnish and install a UL listed prefabricated two-pump water pressure booster system.
1. The system shall be capable of automatically providing a constant system pressure of 75 psig while supplying a flow rate from 0 to 150 GPM with a suction pressure of 20 psig minimum, 60 psig maximum.
2. Refer to scheduled equipment on Contract Drawings for capacities of pumps and motors.

B. Pumps:
1. Pumps shall be single stage end-suction design of cast iron bronze fitted construction, equipped with mechanical shaft seal.
2. Each pump shall have vibration-isolating mounts and be fitted with a separate prewired temperature probe and approved electrical purge valve installed immediately upstream of each check valve.

C. Drip-proof type motor.
1. Each pump motor shall be premium efficient ODP (suitable for use with VFD’s) and operate within the nameplate horsepower at any point on the pump capacity head curve.
2. Each pump shall be fitted with isolation valves and union connections or flanges to facilitate future service requirements.
3. Each pump shall be furnished with a silent check valve with bronze trim.

D. Power and Control Panel:
1. A single point disconnect panel (NEMA 1) shall be skid mounted and factory wired.
a. Factory wiring shall include variable frequency drive wiring, motor wiring, differential pressure switch wiring and low suction pressure switch wiring.
b. Pressure transducer shall be factory mounted at discharge header location, unless shown otherwise on the plans. The pump logic controller shall be provided as the pressure booster control panel and shall have fused door interlock disconnect, local-off-remote switch, motor overload protection, diagnostic display, manual & automatic alternation,

auto start of lag pump on lead failure and accept pump differential pressure switch signals for pump fail notification.

c. The complete assembly shall have the UL listing mark for industrial control panels.

E. Instrumentation and Emergency Controls:
1. Each pump shall have anti-vibration pads, a temperature probe, and an electric purge valve.
2. Include individual pressure gauges for indicating each pump, system, and suction pressure.
3. Include pressure switch for abnormally low suction pressure to activate the automatically reset alarm system.

F. Factory Prefabrication:
1. The entire booster system shall be factory prefabricated on a common structural steel stand with all interconnecting piping and wiring completed and hydrostatically tested prior to shipment.
2. The complete package shall also include isolation valves on the suction and discharge of each pump. Stainless steel suction and discharge pipe manifolds, as well as copper tubing with shutoff cocks for gauges and pressure switches, will be furnished assembled.
3. The only field connections required will be system suction and discharge headers, the temp probe drain tube, piping of the hydropnuematic pressure tank with union ball valve, and the power connection at the control panel.

G. Hydropneumatic Tank:
1. A hydropneumatic tank shall be included by booster skid manufacturer.
2. Tank shall be a full acceptance replaceable bladder style and include a union isolation valve, tank drain and pressure gauge.
3. Tank shall be skid mounted and piped shipped loose for field installation as indicated on the plans.

H. Warranty: The system shall be warranted (including parts and labor) for a period of 12 months from the date of start-up.

I. Manufacturer: SyncroFlo, Patterson #Aqua FloPac, Federal, Paco, or Bell & Gossett.

J. Furnish and install pumps with capacities as shown on plans. Pumps shall be base mounted, single stage, end suction design with true back pull-out, capable of being serviced without disturbing piping connections.

K. Pump volute shall be Class 30 cast iron with integrally cast pedestal support. The impeller shall be cast bronze, enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew. Impeller trim shall be no greater than 85% of the maximum impeller size for the pump.

L. The liquid cavity shall be sealed off at the pump shaft by an internally flushed mechanical seal with ceramic seal seat of at least 98% alumina oxide content, and carbon seal ring, suitable for continuous operation at 225° F. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.

M. Pumps shall be rated for minimum of 175 psi working pressure. Casings shall have gauge ports at nozzles and vent and drain ports at top and bottom of casing.

N. Pump bearing housing assembly shall have heavy duty regreaseable ball bearings, replaceable without disturbing piping connections and have foot support at coupling end.

O. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area. A flexible type coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor, and shall be equipped with an OSHA approved coupling guard. Contractor to level and grout each unit according to manufacturer's instructions.

P. The motor shall meet NEMA specifications and shall be the size, voltage and enclosure called for on the plans. Pump and motor shall be factory aligned, and shall be realigned by contractor after installation. Provide premium efficiency motors in accordance with Section 220500.

Q. Each pump shall be factory tested, it shall then be thoroughly cleaned and painted with at least one coat of high grade machinery enamel prior to shipment.

R. Each unit shall be checked by the contractor and regulated for proper differential pressure, voltage and amperage draw. This data shall be noted on a permanent tag or label and fastened to the pump for owner's reference.

S. Manufacturer: Bell & Gossett series "1510" or approved equal by TACO, PACO, Peerless or Armstrong.

2.2 EXPANSION TANKS

A. Atmospheric:
1. General: Tanks shall be constructed from carbon steel, in conformance with the requirements of ASME Code for a working pressure of 150 psi. Tank shall be fitted with Airtrol tank fitting, an air-charging connection, drain valve, gauge glass, and shall include all tappings and supports. After fabrication all external surfaces of the tank shall be thoroughly cleaned and finished with one coat of air dry enamel.
2. Size and capacity as shown on drawings. Provide reducing valve and accessories as noted on plans or schedules.
3. Manufacturer: Bell & Gossett, TACO, Wheatley or approved equal.

B. Diaphragm Type Pre-pressurized:
1. The pressurization system shall include a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. It shall maintain minimum operating pressure necessary to eliminate all air. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank.
2. The expansion tank shall be welded steel, constructed, tested and stamped in accordance with Section VIII of the ASME Code for a working pressure of 125 psi and precharged to the minimum operating pressure.
3. The manufacturer shall be Wessels, Amtrol or approved equal with at least five years experience in the fabrication of diaphragm-type ASME expansion tanks.

2.3 AIR SEPARATORS

A. Tangential and coalescing media type:
1. All free air originally contained in the system, and all entrained air bubbles carried by system water shall be eliminated at all system points as indicated on the drawings.
2. The air separator shall be welded steel, constructed, tested and stamped in accordance with Section VIII of the ASME Code for a working pressure of 125 psi.
3. Air separators shall be sized as indicated on plans.
4. Provide with strainer unless otherwise noted.
5. Manufacturer: Bell & Gossett, TACO, Wheatley, Armstrong, Spirovent or approved equal.

2.4 AIR ELIMINATION VALVE (AUTOMATIC)

A. Air shall be eliminated to the atmosphere as fast as it is separated from system water, through a float activated remote pressure operated, air elimination valve installed at the top of the air separator.

B. The air elimination valve shall have a high removal rate at low pressure differentials and shall be fully open for the removal of air at all pressures in the operating range from 2 to 150 psig. It shall be tightly sealed against loss of system water and prevent entrance of air in negative pressure situations.

C. The air elimination valve shall be constructed of metal and all working parts shall be non-corrosive. Working pressure shall be 125 psi.

D. Provide minimum 3/8” drain line from vent and route to nearest floor drain or floor sink or other approved drainage location.

E. Manufacturer: Amtrol, Hoffman or approved equal.

2.5 SUCTION DIFFUSERS

A. Furnish and install as shown on plans, an angle pattern flow straightening fitting equipped with a combination diffuser-strainer-orifice cylinder, flow straightening vanes, start-up strainer, permanent magnet and adjustable support foot. The combination diffuser-strainer-orifice cylinder shall be designed to withstand pressure differential equal to the system pump shutoff head and shall have a free area equal to five times the cross section area of the pump suction opening. The length of the flow straightening vanes shall be no less than 2-1/2 times the diameter of the system suction connection.

B. Fitting to be of cast iron construction with flanged connections unless otherwise noted. See plan for sizes.

C. The fitting shall have a stainless steel combination diffuser-strainer-orifice cylinder with 3/16 inch diameter perforation to protect system pump. Provide with stainless steel straightening vanes. Start-up strainer to be 16 mesh bronze. All internal components to be replaceable.

D. Manufacturer: Bell & Gossett, TACO, Wheatley, Victaulic or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All equipment, unless otherwise shown or noted on the Drawings, is to be installed in accordance with industry standards and manufacturer's recommended installation instructions.

B. Grouting Pump Base: For all base mounted flexibly coupled pumps fill the pump base frame with grout after completing pump/motor alignment.

C. Provide vibration isolation, inertia bases, seismic snubber, flexible pipe connections, etc, as specified in related specification sections.

D. For variable flow pumping applications, see Section 230902 Variable Frequency Drives for additional requirements.

E. Contractor to assist testing and balancing contractor in verifying correct pump rotation and system operation.

F. Flush and clean equipment, in accordance with manufacturer's start-up instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls.

G. Isolation for Service: Provide pump installations with a discrete isolation valve on both the supply and intake side of the pump to permit service of the pump and any related strainer, check or balancing valves. Triple duty valves are not equivalent for this shut-off service.

H. Balancing Coordination and Impeller Trimming: Coordinate final pump flow with test and balance contractor. For pumps larger than 5 horsepower, if the system tests and balance indicate that flow exceeds the specified flow by greater than 20%, it is not acceptable to reduce flow merely by adjusting balance valves to create additional head or reducing VFD peak flows. Excess system flow must be reduced by trimming the impeller to match the load.

3.2 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify pump systems mounting, verify piping installation, verify control wiring, verify power wiring, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours travel from the jobsite.

END OF SECTION 221123

SECTION 223400

DOMESTIC HOT WATER HEATING EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this section shall include but not necessarily be limited to the following:
   1. Water heaters
      a. Electric Tank Type
      b. Natural Gas Condensing Tank Type
   2. Expansion Tank
   3. Condensate Neutralizer

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 224000: Plumbing Fixtures

C. Section 235100: Breechings, Chimneys and Stacks

1.3 QUALITY ASSURANCE – WATER HEATERS

A. Manufacturers and Representatives Qualifications. Firms regularly engaged in manufacture of water heating equipment, systems and service shall have been active in the field and whose products have been in satisfactory use in similar service for not less than 5 years.

B. Minimum Efficiency: Minimum efficiencies shall meet or exceed the values required by the local energy code. Water heater shall include automatic temperature control for maintaining leaving water temperature setpoint.

C. ASME Compliance: Condensing water heaters must be constructed in accordance with ASME Water heater and Pressure Vessel Code, Section IV (HLW) Potable Water Heaters.

D. ANSI Compliance: Condensing water heaters must be tested for compliance with ANSI Z21.10.3 (2011) / CSA 4.3 Gas Water Heater. For use as a potable water heater, "American National Standard / CSA Standard for Gas Water Heaters." Condensing water heaters shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.4 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01. Submit manufacturer's data, colors, installation instructions, and maintenance and operating instructions for all components of this section including, but not limited to, the following:
   1. Water heaters
   2. Expansion Tank
   3. Thermostatic Mixing Valve

B. Electrical Work: Refer to Division 22, Section 220500 for requirements and coordinate with Division 26.

C. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.

D. Water Heater Pressure Drop Curve: Submit pressure drop curve for flows ranging from 0 gpm to maximum value of water heater.

E. Wiring Diagrams: Submit manufacturer's electrical requirements for electrical power supply wiring. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation. Differentiate between portions of wiring that are factory installed and portions that are to be field installed.

F. Operation and Maintenance Data: Submit maintenance data and parts lists for each type and size of water heater, control, and accessory, including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual, in accordance with requirements of Division 01. Submit operational manuals.

G. Certificates: Submit appropriate Certificates of Shop Inspection and Data Report as required by provisions of ASME Boiler and Pressure Vessel Code.

H. Start-up: Provide written report on start-up in accordance with Section 220500.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged products - remove from project site.

1.6 COORDINATION

A. Coordinate size and location of concrete bases and attachments with structural design. Coordinate with Divisions 03 for specification of concrete, reinforcement and formwork requirements.

1.7 WARRANTY

A. Provide one year (12 months) warranty from date of Certificate of Occupancy. The warranty shall include repair or replacements of components that fail in materials or workmanship within the warranty period and shall include parts, labor, travel costs, and living expenses to repair or replace products or systems.

B. Tanks shall have a three-year (36 months) warranty against leaks. The warranty shall include replacement parts, labor, travel costs, and living expenses to repair or replace products or systems.

PART 2 - PRODUCTS

2.1 ELECTRIC TANK TYPE HOT WATER HEATER

A. Tank type electrical water heater with integral heating elements and insulated tank. Refer to drawings for locations, capacities, flow rates, power requirements and models.

B. All internal surfaces of the tank shall be glass-lined with an alkaline borosilicate composition that has been fused-to-steel. Tank shall be cathodically protected with adequate extruded magnesium anode. The entire vessel is to be enclosed in a round steel enclosure with baked enamel finish. Tank shall have a 150 psig working pressure. Foam insulated (R-16 minimum) tank to meet or exceed US DOE, ASHRAE/IESNA 90.1 and local energy code requirements.

C. Electric heating elements shall be medium watt density with zinc plated copper sheath. Each element shall be controlled by an individually mounted thermostat and high temperature cutoff switch. Factory wired for non-simultaneous operation. Set initial water heater temperature to 140°F (minimum).

D. Heater shall include ASME pressure and temperature relief valve.

E. Manufacturers: A.O.Smith, Bradford-White, Lochinvar, Rheem or equal.

2.2 WATER HEATER-NATURAL GAS, HIGH EFFICIENCY CONDENSING, TANK TYPE

A. Water heater shall be fully condensing, minimum 95% thermal efficiency, with closed combustion venting. Refer to schedule on drawings for sizing, capacities, recovery rate, power requirements and models.

B. Water heater shall be of a seamless glass lined steel tank construction with sacrificial magnesium anode rods and include a powered natural gas burner with electronic flame safeguard, intermittent ignition, automatic gas valve, and gas pressure regulator. Maximum supply gas pressure to heater 14" W.C. Maximum operating pressure of 150 psig. Bolted hand hole cleanout.

C. Water heater shall be suitable for sealed combustion direct venting using a CPVC air intake pipe and CPVC exhaust pipe for a total distance of 50 equivalent feet of vent (minimum) and 50 equivalent feet of intake (minimum). Termination may utilize a single opening manufactured concentric vent assembly. The heater shall be approved for 2", or less, clearances to combustibles.

D. Water heater controls shall include integrated solid state temperature and direct spark ignition control device with integral diagnostics, LED fault display capability and a digital display of temperature settings.

E. Tank shall be foam insulated and equipped with an ASME rated temperature and pressure relief valve. The water heater shall be UL listed and exceed the minimum efficiency requirements of ASHRAE/IESNA 90.1.

F. Set initial water heater temperature to 140°F (minimum).

G. Manufacturer: A.O.Smith Cyclone BT Series, Bock OT Series, Bradford White EF Series or equal.

2.3 TEMPERATURE AND PRESSURE RELIEF VALVES

A. Temperature and Pressure Relief Valve: Lead free bronze body construction, thermostat and test lever, temperature relief set at 210ºF, and pressure relief set at 125 psi. Certified to meet ASME low pressure heating boiler code and ANSI Z21.22.

B. Manufacturers: Watts #LF Series (100XL, 40, 140, N240, 340), Cash Acme #FVX Series or equal.

2.4 THERMAL EXPANSION TANK

A. Furnish and install one thermal expansion tank in each closed domestic hot water piping system as shown on drawings. Size tank per hot water piping system volume and operating conditions. Minimum three (3) gallon acceptance volume.

B. Construction:
1. Designed and constructed vessel per ASME Code Section VIII, Division 1.
2. Tanks rated for maximum 150 psig working pressure.
3. Steel tank with stainless steel connection and painted.
4. Butyl diaphragm bonded to polypropylene liner. Pre-charged air chamber to 55 psig with Schrader air valve.
5. Tank saddle support for wall or upper attachment support or ring base for floor attachment.

C. Manufacturer: Amtrol Therm-X-Trol, Watts PLT, Adamson, RECO or equal.

2.5 VACUUM RELIEF VALVES

A. Vacuum Relief Valve: Provide on incoming cold water service where hot-water storage tank or indirect water heater is located at an elevation above the plumbing fixture outlets. Lead free brass body

construction, protective cap, 1/2” male NPT, maximum operating temperature 250°F. Tested and rated to ANSI Z21.22.

B. Manufacturers: Watts #LFN36 Series, Cash Acme #VR-801, or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Examine areas and conditions under which equipment is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected. Refer to drawings and other specification sections for locations, dimensions and features required for each piece of equipment.

B. Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

C. Orient equipment so controls and devices needing service and maintenance have adequate access and code required clearances.

D. Connect piping with shutoff valves and unions as required for maintenance and system isolation.

E. Connect all drain outlets and route to approved termination locations as shown on the drawings and as required by code.

F. Start-Up: Start-up, test, and adjust equipment in accordance with manufacturer's start-up instructions. Check and calibrate controls. Start-up to be by authorized manufacturer's representative or agent.

3.2 WATER HEATER EXAMINATION

A. Before water heater installation, examine roughing-in for equipment bases, anchor-bolt sizes and locations. Examine piping and electrical connections to verify actual locations, sizes and other conditions affecting water heater performance, maintenance and operations.
   1. Final water heater locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where equipment heaters will be installed. Coordinate with Owner’s Representative if there are concerns about proposed equipment locations. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 WATER HEATER INSTALLATION

A. Install water heaters and tanks level on bases or platforms as required and as shown on drawings. Coordinate with Division 03 for concrete materials and installation requirements.

B. Install water heaters in accordance with local, state, provincial, and national codes, laws, regulations, and ordinances.

C. Comply with manufacturer’s installation instructions, including required service clearances and venting guidelines.

D. Provide seismic anchorage attachments on vertical tanks heaters with support points at upper 1/3 and lower 1/3.

E. Assemble and install water heater ASME listed Pressure/Temperature Relief Valve.

F. Install electrical devices furnished with water heater but not specified to be factory mounted.

G. Install control wiring to field-mounted electrical devices.

3.4 WATER HEATER CONNECTIONS

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

B. Install piping adjacent to water heater to permit service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection and pitched for gravity flow.

D. For condensing water heaters, provide condensate neutralizer in condensate drain pipe before termination at floor sink or other approved termination.

E. Connect gas piping to water heater gas valve with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required at final connection.

F. Install flue venting and combustion air intake duct full size to water heater connections.

G. Connect cold and hot water piping to inlet and outlet connections with shutoff valves and dielectric union or flanges at each connection.

H. Install piping from safety pressure and temperature relief valves to nearest floor sink or to the exterior of the building.

I. Install vacuum relief valve in incoming cold water pipe to water heaters.

J. Provide one (1) glass thermometer and thermowell in the hot water pipe on the discharge side of the water heater or water heating system. Thermowell shall be brass or stainless steel. Install thermowell into tee fitting within 36” of water heater outlet. Thermowell may be installed horizontally or vertically, but thermometer must be mounted vertically and positioned for easy reading from a standing position. Adjust installation of thermometer and thermowell to extend no more than 2” into water flow path. Thermowell probe shall not restrict the water flow in the hot water pipe, therefore the tee fitting must be enlarged. Tee fitting diameter shall be oversized to equal, or exceed, the diameter of the supply water pipe plus the diameter of thermowell for the entire depth of thermowell probe.

K. Drain valve shall be readily accessible for installation of hose to facilitate maintenance draining. Elevate water heater and tanks, as necessary, to accommodate hose connection. See drawings for additional requirements.

L. Ground equipment according to Division 26 Section - Grounding and Bonding for Electrical Systems.

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

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections
   1. Installation and Startup Test: Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion, if necessary.

4. Controls and Safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

D. Occupancy Adjustments: When requested within 2 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.6 OPERATION MANUALS, START-UP SERVICE, WARRANTIES, ACCEPTANCE AND GUARANTEES

A. General: Refer to Section 220500 for requirements.

END OF SECTION 223400

SECTION 224000

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this section shall include, but not necessarily be limited to, the installation of plumbing fixtures and trim.

1.2 RELATED WORK IN OTHER SECTIONS

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 223000: Plumbing Equipment

1.3 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01. Submit manufacturer's data, colors, installation instructions, and maintenance and operating instructions for all components of this section including, but not limited to, the following:
1. Plumbing fixtures.
2. Piping specialties.
3. Toilets.
4. Urinals.
5. Lavatories.
6. Sinks.
7. Showers or tubs.

B. Shop Drawings: Submit rough-in drawings. Detail dimensions, rough-in requirements, required clearances, and methods of assembly of components and anchorages. Coordinate requirements with Architectural Woodwork shop drawings specified in Division 06 for fixtures installed in countertops and cabinets. Furnish templates for use in woodwork shop.

C. Samples: Submit samples of any piece of equipment requested by Architect for review and approval.

D. Wiring Diagrams: Submit manufacturer's electrical requirements and wiring diagrams for power supply to units. Clearly differentiate between portions of wiring that are factory installed and field installed portions.

1.4 CODES AND STANDARDS

A. Uniform Plumbing Code (UPC) with State Amendments.

B. All fixtures and faucets must meet all requirements of Americans with Disabilities Act (ADA).

C. State Energy Code

D. ARI Standard 1010: “Drinking Fountains and Self-Contained Mechanically Refrigerated Drinking Water Coolers.”

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged products. Remove damaged products from project site.

1.6 MAINTENANCE

A. Extra Stock:
1. Furnish special wrenches and other devices necessary for servicing plumbing fixtures, flush valves, and trim to Owner's Representative with receipt in a quantity of one device for each 10 fixtures.
2. Furnish faucet repair kits complete with all necessary washers, springs, pins, retainers, packings, o-rings, sleeves, and seats in a quantity of 1 kit for each 10 faucets.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide fixtures as specified. Fixtures in any secure or public areas shall be vandal proofed.

B. Architect/Engineer shall review and approve any substitution requested by Contractor prior to bid submittal.

C. Provide fixture as specified, acceptable manufacturers:
1. Vitreous China or Cast Iron Fixtures: American Standard, Eljer, Zurn or Kohler.
2. Stainless Steel Sinks: Elkay or Just
a. All stainless steel is 18 gauge, type 304 unless otherwise specified.
3. Drinking Fountains: Elkay or Haws.
4. Terrazzo Service Sinks: Florestone or Stern Williams.
5. Showers enclosures: Lasco, Fiber Fab, Aquaglass and Aqua Bath.

D. Provide faucet as specified. Acceptable manufacturers: Chicago Faucets, Zurn, Symmons, T and S or as indicated.

E. Provide commercial grade toilet seat as specified. Manufacturers: Beneke, Bemis, Church or Olsonite.

F. Provide standard grade P-Traps and supplies with stops as specified in residences. Provide supplies meeting AB1953 no lead requirements. Lavatory supplies shall be 1/2" x 3/8" x 12" ground joint flexible riser with round wheel handles and chrome plated IPS brass nipple. Sink supplies shall be 1/2" x 12" ground joint flexible riser with round wheel handle angle stop with chrome plated IPS brass nipple. Provide bell type chrome plated escutcheon for traps and supplies. Manufacturers: McGuire, Zurn, Chicago, Brasscraft or equal.
1. P-Trap Lavatory: McGuire 8901-C or Zurn 8706.
2. P-Trap Sink: McGuire 8892-C or Zurn 8708.
3. Supply Lavatory: McGuire LF2165 or Zurn ZH8801-XL-LR.
4. Supply Sink: McGuire LF2167 or Zurn ZH8803-XL-LR.
5. Supply Water Closet: McGuire 2169 or Zurn Z8807CR.
6. Offset Supply for ADA Lavatory: McGuire 158W or Zurn Z-8855-WL.
7. Offset Trap Arm for ADA Lavatory: McGuire 155WC or Zurn Z-8746.
8. Offset Trap Arm for ADA Sink: McGuire 1151AWC or Zurn Z-8749.
9. Escutcheons: McGuire chrome plated WE125TR, WE150, WE125D and WE150D or Zurn.

G. Insulation: provide white molded closed cell vinyl pre-fab insulation on P-Trap and on both hot and cold water supply for barrier free lavatories and sinks. Bag type insulators are not acceptable. Manufacturers: Plumberex, True-Bro, Zurn or equal.

2.2 LISTING

A. Refer to plumbing fixture schedule on drawings for manufacturers, model numbers and selection criteria.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify all dimensions by field measurements. Verify that all plumbing fixtures may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Examine rough-in for potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures.

C. Examine walls, floors and cabinets for suitable conditions where fixtures are to be installed.

D. Install plumbing fixtures level and plumb, in accordance with fixture manufacturer's written instructions, rough-in drawings, and pertinent codes and regulations, the original design, and the referenced standards.

E. Comply with the installation requirements of ADA with respect to plumbing fixtures for the physically handicapped.

F. Fasten plumbing fixtures securely to supports or building structure. Secure supplies behind or within wall construction to provide rigid installation.

G. Install a stop valve in an accessible location in the water connection to each fixture.

H. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork.

I. Seal fixtures to walls and floors using sealants as specified in Division 07. Match sealant color to fixture color.

J. Install P-Trap tight to outlets from lavatories and shower drains to minimize the vertical water drop and related drainage noise. Outlet drops longer than 7” to P-trap water level are not acceptable.

K. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning units, then retest.

L. Inspect each installed unit for damage. Replace damaged fixtures.

M. Adjust water pressure at drinking fountains, faucets, shower valves, and flush valves to provide proper flow stream.

N. Replace washers or cartridges of leaking or dripping faucets and stops.

O. Clean fixtures, trim, and strainers using manufacturer's recommended cleaning methods and materials.

P. During construction cover all installed fixtures, sinks, and water coolers with cardboard boxes and wrap with Visqueen.

END OF SECTION 224000

SECTION 230500

BASIC HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE OF THIS SECTION

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Compliance with all codes and standards applicable to this jurisdiction
   2. Shop Drawings for Equipment
   3. Coordination Documents
   4. Record Drawings
   5. Start-up Service and Building Commissioning
   6. Instruction, Maintenance, and O & M Manuals
   7. Work associated with Delivery, Storage, and Handling of products
   8. Work associated with provision of Temporary Facilities
   9. Preparation of Posted Operating Instructions
   10. Meeting Project Safety and Indemnity requirements
   11. Proper Cleaning and Closing
   12. Supplying proper Warranty information
   13. Supply specified Guarantee documentation
   14. Design and provision of Supports and Anchors
   15. Pipe Portals
   16. Pipe Supports
   17. Equipment Rails
   18. Access Doors
   19. Identification Markers
   20. Coordination of Electrical requirements for equipment provided

1.2 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to provide all material and labor to install complete heating, ventilating, air conditioning systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and shall coordinate this work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the fixtures, equipment, and pipe lines and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing site systems, every effort has been made to note existing utilities and services. However, the Contractor should thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all mechanical system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for

specific attachment requirements. The mechanical system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply mechanical devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with ductwork and piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

1.3 DESCRIPTION OF BID DOCUMENTS

A. Specifications:
1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:
1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and methods of installation.
2. Before proceeding with work check and verify all dimensions.
3. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
4. Make adjustments that may be necessary or requested, in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
5. Where existing pipes, conduits and/or ducts prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits and/or ducts. Verify exact location and elevation of existing piping prior to any construction.
6. If any part of Specifications or Drawings appears unclear or contradictory, apply to Owner's Representative interpretation and decision as early as possible, including during bidding period.

1.4 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.

B. Accessible: Ability to perform recommended maintenance without removal of services or equipment and requiring no special platforms.

C. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

D. Below Grade: Buried in the ground or embedded in concrete slab on ground.

E. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

F. Connect: Complete hook-up of item with required service.

A. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.

G. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements.

H. Exposed: Not installed underground or concealed.

I. Furnish: To supply equipment and products as specified.

J. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.

K. Install: To erect, mount and connect complete with related accessories.

L. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

M. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

N. NRTL: Nationally Recognized Testing Laboratory, including UL and/or ETL.

O. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

P. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

Q. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner's Representative.

R. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

S. Shall: An exhortation or command to complete the specified task including providing and installing work associated with task.

T. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

U. Supply: To purchase, procure, acquire and deliver complete with related accessories.

V. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

W. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall".

X. Wiring: Raceway, fittings, wire, boxes and related items.

Y. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.5 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 23 Mechanical sections included herein.

B. Division 33: Utility Site Work.
   1. Coordination of excavation of trenches and the installation of mechanical systems and piping on site.

C. Division 03: Concrete.
   1. All concrete work required for mechanical work shall be coordinated by Division 23 with Division 03 including:
      a. Concrete curbs and housekeeping pads for the mechanical equipment.
      b. Thrust blocks, pads, and boxes for mechanical equipment.

D. Division 07: Thermal and Moisture Protection.
   1. Flashing and sheet metal.
   2. Sealants and caulking.
   3. Firestopping.

E. Division 09: Painting.
   1. Division 23 shall coordinate with Division 09 to perform all painting, except where specifically stated otherwise in Division 09.
   2. Painting of all exposed steel, piping, ductwork, insulation, equipment and materials
   3. Paint all exposed gas piping, interior and exterior to the building, yellow.

F. Division 10: Miscellaneous Metals.
   1. Exterior louvers and grilles shall be included in this Section.

G. Division 26: Electrical.
   1. Power connections to all mechanical equipment

H. Division 28: Electronic Safety and Security.
   1. Fire protection alarms and relays.
   2. Smoke detector and monitoring.
   3. Life safety systems.

1.6 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 23 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All accessible mechanical work shall comply with the minimum requirements of the Americans with Disabilities Act (ADA) and local amendments. Refer to Architectural drawings and specifications for additional ADA requirements. The following requirements are provided as consolidated list of minimum ADA requirements. Compliance requirements applicable to HVAC work includes, but is not limited to, the following:
   1. Section 309: Operable parts shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate operable parts shall be 5 pounds maximum.
   2. Section 308.3: Temperature control devices mounted on walls with operable buttons or switches shall be placed where clear floor or ground space allows a parallel approach and the side reach is unobstructed. Operable parts shall be located 48” maximum above finished floor. Do not mount above light switches to avoid inaccurate temperature readings due to light switch heat output.
   3. Section 308.3.2: Where a clear floor or ground space allows a parallel approach to an element and high reach is over an obstruction, the height of the obstruction shall be 34” maximum and depth of obstruction shall be 24” maximum.
   4. Section 404.2.9: Fire doors shall have a minimum opening force allowable by the applicable Building Code. The force for pushing or pulling open a door other than fire doors shall be 5 pounds maximum.

E. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

F. Provide in accordance with rules and regulations of the following:
1. California Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2019 Building Standards Administrative Code, Part 1, Title 24 California Code of Regulations (CCR).
   b. 2019 California Building Code (CBC), Part 2, Title 24 CCR (2018 International Building Code with California Amendments).
   c. 2019 California Electrical Code (CEC), Part 3, Title 24 CCR (2017 National Electrical Code with California Amendments).
   d. 2019 California Mechanical Code (CMC) Part 4, Title 24 CCR (2018 Uniform Mechanical Code with California Amendments).
   e. 2019 California Plumbing Code (CPC), Part 5, Title 24 CCR (2018 Uniform Plumbing Code with California Amendments).
   f. 2019 California Energy Code (CEC), Part 6, Title 24 CCR.
   g. 2019 California Fire Code, Part 9, Title 24 CCR (2018 International Fire Code with California Amendments).
   h. 2019 California Green Building Standards Code (CALGreen), Part 11, Title 24 CCR.
   i. 2019 California Referenced Standards, Part 12, Title 24 CCR.
   j. Title 19 CCR Public Safety, State Fire Marshal Regulations.
2. Oregon Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2019 Oregon Structural Specialty Code (OSSC) based on 2018 International Building Code (IBC).
   b. 2019 Oregon Energy Efficiency Code (OEESC) based on the 2018 International Energy Conservation Code (IECC).
   c. 2019 Oregon Mechanical Specialty Code (OMSC) based on 2018 International Mechanical Code (IMC) and 2018 International Fuel Gas Code (IFGC) with State Amendments.
   d. 2017 Oregon Plumbing Code (OPC) based on 2015 Uniform Plumbing Code (UPC) with State Amendments.
   e. 2014 Oregon Fire Code (Based on the 2012 International Fire Code.)
   f. 2017 Oregon Electric Specialty Code (Based on the 2017 National Electric Code (NEC) with State Amendments.
3. Washington Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2015 International Building Code (IBC) with State Amendments.
   b. 2015 International Mechanical Code (IMC) with State Amendments.
   c. 2015 Uniform Plumbing Code (UPC) with State Amendments.
   d. 2015 International Fire Code (IFC) with State Amendment.
   e. 2015 National Fuel Gas Code (NFGC) NFPA 54, WAC 51-52.
   f. 2017 National Electrical Code (NEC).
   g. 2015 Washington State Energy Code, (WAC 51-11, WSEC).
   h. Washington State Ventilation and Indoor Air Quality Code, WA 51-13 (VIAQ).
4. Nevada Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2018 International Building Code (IBC) with State Amendments.
   b. 2018 Uniform Mechanical Code (UMC) with State Amendments.
   c. 2018 Uniform Plumbing Code (UPC) with State Amendments.
   d. 2018 International Fire Code (IFC) with State Amendments.
   e. 2017 National Electric Code (NEC) with State Amendments.
   f. 2018 International Energy Conservation Code (IECC) with Amendments.
5. Texas Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2015 International Building Code (IBC) with State and Local Amendments.
   b. 2015 International Mechanical Code (IMC) with State and Local Amendments.
   c. 2015 International Plumbing Code (IPC) with State and Local Amendments.
   d.
   e. 2017 National Electric Code (NEC) with State and Local Amendments.
   f. 2015 International Energy Conservation Code (IECC) with Amendments.
   g. 2015 Uniform Mechanical Code (UMC) with State and Local Amendments for Austin.

h. 2015 Uniform Plumbing Code (UPC) with State and Local Amendments for Austin.

6. Federal Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2018 International Building Code (IBC).
   b. 2018 International Mechanical Code (IMC).
   c. 2018 International Plumbing Code (IPC).
   d. 2018 International Fire Code (IFC).
   e. 2018 International Energy Conservation Code (IECC).
   f. 2017 National Electric Code (NEC).
7. Local, city, county and state codes and ordinances.
8. Local Bureau of Buildings.
9. Local Health Department.
10. Local and State Fire Prevention Districts.
11. State Administrative Codes.

G. Provide in accordance with appropriate referenced standards of the following and as referenced in other specification sections:
1. NFPA - National Fire Protection Association
2. AABC - Associated Air Balance Council
3. CSA - Canadian Standards Association
4. ADC - Air Diffuser Council
5. AMCA - Air Moving and Conditioning Association
6. ANSI - American National Standards Institute
7. ARI - Air Conditioning and Refrigeration Institute
8. ASHRAE - American Society of Heating, Refrigerating & Air Conditioning Engineers
9. ASME - American Society of Mechanical Engineers
10. ASTM - American Society for Testing Materials
11. AWS - American Welding Society
12. FM - Factory Mutual
13. International Building Code (IBC) Chapter 16.
14. ASCE 7-10 – American Society of Civil Engineers – Minimum Design Loads for Buildings and Other Structures.
15. ICC AC156 Seismic Certification by Shake-Table Testing of Nonstructural Components.
16. MSS - Manufacturer's Standardization Society
17. NEMA - National Electrical Manufacturer's Association
18. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
19. UL - Underwriter's Laboratories
20. ADA - Americans with Disabilities Act
21. ETL - Electrical Testing Laboratories.

H. Provide compliance in accordance with the following referenced standard which applies to general system compliance in contrast to specific equipment standards referenced elsewhere:
1. UL-2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces. This is applicable to spaces above suspended ceilings and below raised floors.

1.7 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner’s Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the

context of requirements. Refer uncertainties to the Owner's Representative for a decision before proceeding.

1.8 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be metallic riveted or bolted to the manufactured item, with nameplate data engraved or punched to form a non-erasable record of equipment data suitable for the ambient exposure.

B. All work shall include the following:
   1. Manufactured items and equipment shall be a current, cataloged product of the manufacturer.
   2. Replacement parts shall be readily available and stocked in the USA.

C. Experience: Unless more stringent requirements are specified in other sections of Division 23, manufactured items shall have been installed and used, without modification, renovation or repair, on other projects for not less than one year prior to the date of bidding for this project.

D. Each product and/or equipment type shall be provided by one manufacturer. Mixtures of manufacturers for each product and/or equipment type are not acceptable. Example – all fire dampers shall be supplied by one manufacturer.

E. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.

F. Welding Standards:
   1. Welding Qualifications:
      a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The welder must maintain their certification to show qualified welding experience every six months. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.
   2. Welding Procedures:
      a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
      b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

G. Pressure Piping Standards
   1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-Building Services Piping standards for materials, products, and installation per pressure and temperature operating class.
   2. Comply with ASME B31.9 Building Services Piping standard for the following services:
      a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
      b. Fluid pressure less than 350 psig.
   3. Comply with ASME B31.1 Power Piping standard for the following services:
      a. Steam.
   4. Comply with ASME B31.3 Process Piping standard for the following services:
      a. Conveying fluid above 250°F (121°C).
      b. Toxic or flammable fluids.

1.9 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permit, licenses, fees and inspections, including, but not limited to, building permits, planning permits, air quality management district permits, operating licenses, utility district fees, special district fees, environmental impact reports, and additional local permits and fees.

D. Prepare a Construction IAQ Management Plan meeting the SMACNA IAQ guidelines. See Section 233113 Air Distribution for a summary of requirements.

E. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access. Joints and fittings shall not be located in inaccessible locations such wall, floor and roof penetrations.

F. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to Equipment Specifications for rough-in requirements.

G. Coordinate mechanical equipment and materials installation with other building components.

H. Ductwork and piping dimensions, as identified on drawings and in specifications, refer to the interior free dimensions. Adjust work as necessary to account for larger outside dimensions to account for material wall thickness. Upsize plastic pipe diameters as necessary to maintain minimum interior dimensions.

I. Verify all dimensions by field measurements.

J. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.

K. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

L. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

M. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Contractor shall provide for all cutting and patching required for installation of this work unless otherwise noted.

N. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

O. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

P. Coordinate the installation of mechanical materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, and other installations.

Q. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

R. Coordinate with Owner's Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

S. All materials (such as supports, gaskets, sealants, insulation, ductwork, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall be noncombustible or have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Coordinate with all disciplines to assure that all discrete electrical, plumbing and mechanical products located in plenums are non-combustible and compliant with UL 2043.

T. Coordinate installation of floor drains and floor sinks with work of other trades, such that finished floor slopes to drains and floor sinks are flush with surrounding floor.

U. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

1.10 MINOR DEVIATIONS

A. The Drawings are diagrammatic and show the general arrangements of all mechanical work and requirements to be performed. It is not intended to show or indicate all offsets, fittings, and accessories which will be required as a part of the work of this Section.

B. The Contractor shall review the structural and architectural conditions affecting their work. It is the specific intention of this section that the contractor's scope of work shall include:

C. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications

D. Minor deviations from the mechanical plans required by architectural and structural coordination.

E. The Contractor shall study the operational requirements of each system, and shall arrange work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems from the physical space available for use by this section. This requirement extends to the Contractor's coordination of this section's work with the "Electrical Work". Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

F. Minor deviations to avoid conflict shall be permitted where the design intent is not altered.

G. Advise the Owner's Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

1.11 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner's Representative for approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Delegated-Design Submittal: For structural pipe and equipment supports, vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic, and where required wind forces required to select vibration isolators, seismic and wind restrains, support framing members, and for deigning vibration isolation bases.
   2. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment and cantilever loads. Provide base with level top surfaces with integral sloping on bottom to match support structure.

E. Submittals and Shop Drawings:
   1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner’s Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
   2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
   3. Paper submittals will only be acceptable if specifically required by Division 01.
   4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.12 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.
   1. The shop drawings shall serve to record the coordination of the installation and location of all HVAC equipment, ductwork, grilles, diffusers, piping, fire sprinklers, lights, audio/video systems, electrical services and all system appurtenances.
   2. The Drawings shall include all mechanical rooms and floor plans.
   3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner’s Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner’s Representative.
   4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:
   1. Two dimensional AutoCAD / Revit based documents:
      a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
      b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the HVAC work.
      c. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
      d. Drawings shall incorporate all addenda items and change orders.
      e. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.
   2. Three dimensional Revit / BIM based documents (if required for project):
      a. Provide three dimensional Revit model and BIM input information locating all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
      b. Contractor shall obtain Revit model and BIM input from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
      c. Model shall indicate locations of all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
      d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
      e. Model shall incorporate all addenda items and change orders.
      f. Distribute Revit model and BIM input information to all other trades and provide additional coordination as needed to assure adequate space for equipment and piping and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner’s Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner’s Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

F. Provide copy of Record Drawings to Testing and Balancing Contractor for their use when doing their work.

1.13 REQUESTS FOR INFORMATION (RFIS)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).
   1. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
   2. RFIs shall address single questions and related issues only.

3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
   1. Project name.
   2. Project number.
   3. Date.
   4. Name of Contractor.
   5. Name of Architect and/or Construction Manager.
   6. RFI number, numbered sequentially and unique.
   7. RFI subject.
   8. Specification Section number and title and related paragraphs, as appropriate.
   9. Drawing number and detail references, as appropriate.
   10. Field dimensions and conditions, as appropriate.
   11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
   12. Contractor's signature.
   13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
       a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response to each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following business day.
   1. The following Contractor-generated RFIs will be returned without action:
      a. Incomplete RFIs or inaccurately prepared RFIs.
      b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
      c. RFIs addressing multiple unrelated issues.
      d. Requests for approval of submittals.
      e. Requests for approval of substitutions.
      f. Requests for approval of Contractor's means and methods.
      g. Requests for information already indicated in the Contract Documents.
      h. Requests for adjustments in the Contract Time or the Contract Sum.
      i. Requests for interpretation of Engineer's actions on submittals.
   2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.14 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked "Record Set" at the job site at all times and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e. – valves, traps, strainers, expansion compensators, tanks, etc.).

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. Provide copy of Record Documents to Testing and Balancing Contractor and Commissioning Agent for use when performing their work.

E. At the completion of the construction transfer all “Record Set” notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

F. Refer also to Division 01 for full scope of requirements.

1.15 START-UP SERVICE AND BUILDING COMMISSIONING

A. Prior to start-up, be assured that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of air conditioning units, temperature controls, chillers, boilers, pumps, and other major pieces of equipment. Certify in writing compliance with this Paragraph, stating names of personnel involved and the date work was performed.

C. Provide certificates of calibration for all sensors required for control and monitoring including temperature and pressure.

D. Refer to other Division 23 Sections for additional requirements.

1.16 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. O&M Manuals: Upon completion of the work, and prior to training of Owner's personnel, the Contractor shall submit to the Owner’s Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section, bound in a durable binder. Refer to Division 01.

B. Contractor shall be responsible for providing proper instruction of the of Owner's personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 23. Training is to be appropriate to the complexity of the equipment. The Contractor shall develop and submit training materials prior to this training. These materials shall include qualifications of the trainer, training agenda, learning objectives, and a written test to be administered at the end of the training session. Operation and Maintenance manuals must present, incorporated and referenced in the training sessions.

1.17 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment showing signs of rust shall be removed from site and replaced with new.

C. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

D. Preliminary List of Materials and Unit Price Items: Within thirty (30) days after awarding of the Contract, submit to Owner's Representative for preliminary approval a complete list of manufacturer's names and model numbers of proposed materials and equipment. Also include proposed list of unit price items for review.
   1. Indicate substituted items.
   2. Identify test and balancing agency.
   3. Identify independent testing laboratory for water analysis.

E. The Contractor shall submit with preliminary list of materials a unit price list for each item furnished on this project. Included with price shall be labor cost index.

F. Submittals and Shop Drawings shall be submitted as a complete package bound in a 3-ring binder with tabs for each specification section. Submit six (6) typed copies of submittals. Refer to Division 01 for additional requirements.

G. Refer to Division 01 for the requirements of temporary water and sewer for construction and safety. Provide temporary heating, air conditioning, ventilation, water, and sewer, etc. services as necessary during the construction period and as required to maintain operation of existing systems.

H. Temporary Heating for Commissioning Tests:
   1. Provide temporary heating where needed to provide false load for commissioning tests.
   2. Temporary heating may be from the permanent heating system of the project or from a dedicated temporary heating system. If temporary system is necessary, select facilities known to be safe and without deleterious effect upon what work in place or being installed.

I. Temporary Cooling for Commissioning Tests:
   1. Provide temporary cooling where needed to provide false load for commissioning tests.
   2. Temporary cooling may be from the permanent cooling system of the project or from a dedicated temporary cooling system. If temporary system is necessary, select facilities known to be safe and without deleterious effect upon the work in place or being installed.

1.18 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.19 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.

B. No act, service, Drawing, review, or Construction Review by the Owner's Representative, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages

arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner's Representative, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.20 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner's Representative.

1.21 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.22 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after Substantial Completion, ordinary wear and tear excepted.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words “or approved equal” shall be considered to be subsequent to all manufacturers’ names used herein, unless specifically noted that substitutes are not allowed.

2.2 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:
   1. UL and FM Compliance: Provide products, which are UL listed and FM approved.
   2. ASCE 7 (Latest Edition): American Society of Civil Engineers-Minimum Design Loads for Buildings and Other Structures.
   3. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
   4. SMACNA: Seismic Restraint Manual: Guidelines for Mechanical Systems.
   5. NFPA: Pamphlet number 13 and 14 for fire protection systems.
   6. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.
   7. Manufacturer: Mason Industries, Hilti Inc., B-Line/Tolco (Eaton), Anvil, Erico, Kin-Line, Simpson Strong-Tie Co. Inc., Superstrut, Empire, PHD Manufacturing, Carpenter & Paterson, Powers Fasteners or equal.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS SP-58 types listed.
   1. Adjustable Steel Clevis Hangers: MSS Type 1.
   2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
   3. U-Bolts: MSS Type 24.
   4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
      a. Plate: Unguided type.
      b. Plate: Guided type.
      c. Plate: Hold-down clamp type.
   5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
   6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
   7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
   1. Upper Attachment Side Beam Bracket: MSS Type 34
   2. Upper Attachment Side Beam Angle Bracket: MSS Type 34, UL listed and FM Approved.
   8. Single Pipe Roller with Malleable Sockets: MSS Type 41. Rollers are not required for hydronic piping where spring hangers are utilized.
   9. Adjustable Roller Hangers: MSS Type 43. Rollers are not required for hydronic piping where spring hangers are utilized.
   10. Pipe Roll Stands: MSS Type 44.
   11. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp type by many manufacturers.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8 and or four-bolt riser clamps for heavy loads, MSS Type 42. Provide with 1" thick (minimum) neoprene pad on floor with 1/4" thick steel plate to distribute riser clamp weight to pad.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.
1. Steel Turnbuckles: MSS Type 13.
2. Steel Clevises: MSS Type 14.
3. Swivel Turnbuckles: MSS Type 15.
4. Malleable Iron Eye Sockets: MSS Type 16.
5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated by the Structural Engineering design, provide factory-fabricated building attachments of one of the following types listed.
1. Concrete Inserts:
   a. MSS Type 18.
   b. Manufacturers: Hilti #KCS-MD (for metal deck) or HCI-WF (for wood forms), Simpson Strong Tie #Blue Banger Hanger, Powers Fasteners #Bang-It (for metal deck) or #Wood-Knocker (for wood forms), or equal.
2. Steel Brackets: One of the following for indicated loading:
   a. Light Duty: MSS Type 31.
   b. Medium Duty: MSS Type 32.
   c. Heavy Duty: MSS Type 33.
3. Horizontal Travelers: MSS Type 58.
4. Concrete Screw Anchors: For floor mounted attachments with maximum allowable pullout and shear force of 250 lbs. (1.1 kN) per anchor regardless of size.
   a. Manufacturers: Hilti #Kwik Hus EZ-I, Simpson Strong-Tie #Titen HD (or Rod Hanger version), Powers Fasteners #Wedge-Bolt+ (Screw Anchor), Powers Fasteners #Vertigo+ (Rod Hanger), Powers Fasteners #Snake+ (Internally Threaded Screw Anchor), or equal.
5. Torque-Controlled Expansion Anchor:
   a. Manufacturers: Hilti #Kwik Bolt TZ, Simpson Strong Tie #Strong-Bolt 2, Powers Fasteners #Power-Stud+ SD1 or Power-Stud+ SD2, or equal.
3. Screws and Bolts:
   a. Manufacturers: Bolt Depot, Fastenal, National Bolt & Nut, or equal.
4. Eye Bolts:
   a. Manufacturers: Lawson Products, Sierra Pacific, US Cargo Control, or equal.
5. Powder-Driven Concrete Anchors:
   a. Only for existing concrete structures with minimum 4000 psi concrete compressive strength.
   b. Minimum embedment of 1" (25 mm).
   c. Maximum allowable load of 50 lbs (0.2 kN) per anchor.
   d. Manufacturer: Hilti #X or D Series, Powers Fasteners #CSI Series, or equal.

G. Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping at hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with adjacent pipe insulation.
1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.

2. Insulation Protection Shields: MSS Type 40, 18" minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert. Shield and insulation length shall be 4” for pipe diameters up to 2”, length shall be 6” for pipe sizes 2-1/2” to 6”, and 12” length (minimum) for sizes greater than 12” diameter. Alternate Shield: Polyisocyanurate Urethane with a minimum flexural strength of 60 psi, fully encased in SnappItz #360 PVC for pipe sizes to 6” diameter.
4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain tubing and joint insulation at clevis hangers and strut-mounted clamps.
   a. Manufacturers: Hydra-Zorb #Klo-Shure Insulation Couplings or equal.

H. Miscellaneous Materials:
1. Metal Framing: Provide products complying with NEMA STD ML1.
2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of one-part cement to three-parts sand by volume, with minimum amount of water required for placement and hydration.
4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.
5. Pipe Brackets: Copper plated brackets and supports for various mounting options. Insulate brackets attached to metal studs with felt.
   a. Manufacturers: Holdrite or equal.

2.3 PIPE PORTALS

A. Where pipe portals are not provided by other sections of Specification, provide prefabricated insulated pipe portals as required for piping penetrating through the roof where shown on plans. Field built pipe portals are acceptable alternatives - provide detail of construction for review.

B. Standard pipe portals, unless otherwise noted, shall be constructed as follows:
1. Curb shall be constructed of heavy gauge galvanized steel with continuous welds on shell seams.
2. Insulation to be 1-1/2" thick, 3 lb. density rigid fiberglass.
3. Curb to have a raised 3" (minimum), 45° cant.
4. Curb to have 1-1/2" x 1-1/2" wood nailer (minimum).
5. Curb height to be 8" (minimum) above roof deck.
6. Cant strips shall be raised to match roof insulation thickness.
7. Cover or flashing to be constructed of galvanized steel or other suitable material to provide sturdy weather tight closure. Provide collars and rubber nipples with draw bands of sizes required by piping. Size curb, cover and nipples per manufacturer's recommendations.

C. Manufacturer: Roof Products Systems, Pate, or equal.

2.4 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping. Coordinate all pipe stands with structural design. Select stands for rated support weight and spacing. Refer to details on drawings for permanent fixed roof support and curbs.

B. Compact Pipe Stand:
   1. Adjustable strut-based support stands shall only be used as intermediate support points between permanent fixed stands/supports as required to prevent pipe from sagging.
   2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
   3. Base: Single piece, vulcanized rubber, molded polypropylene or polycarbonate.
   4. Hardware: Galvanized or stainless steel.
   5. Manufacturers: Dura-Blok, Roof Top Blox, Roof Products Systems, nVent CADDY Pyramid, Portable Pipe Hangers, or equal.
   6. Accessories: Mount on protective roof pad with a minimum of 6" material extending beyond all edges to allow for future pipe movement. Nonwoven pad shall be constructed spaghetti-like strands of flexible plastic with UV inhibitor and rated for -40°F to 180°F (-40°C to +82°C). Manufacturer: Yellow Spaghetti or equal.

C. Single-Pipe Stand:
   1. Adjustable strut-based support stands shall only be used as intermediate support points between permanent fixed stands/supports as required to prevent pipe from sagging.
   2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
   3. Base: Single piece, vulcanized rubber, molded polypropylene, or polycarbonate.
   4. Vertical Members: Two, galvanized or stainless steel, continuous-thread 1/2-inch (12-mm) rods.
   5. Horizontal Member: Adjustable horizontal, galvanized or stainless-steel pipe support channels.
   6. Pipe Supports: Roller, strut clamps, clevis hanger or swivel hanger.
   7. Hardware: Galvanized or stainless steel.
   8. Manufacturers: Dura-Blok, Roof Products Systems, nVent CADDY Pyramid, Portable Pipe Hangers, or equal.
   9. Accessories: Mount on protective roof pad with a minimum of 6" material extending beyond all edges to allow for future pipe movement. Nonwoven pad shall be constructed of spaghetti-like strands of flexible plastic with UV inhibitor and rated for -40°F to 180°F (-40°C to +82°C). Manufacturer: Yellow Spaghetti or equal.

D. Multiple-Pipe Stand:
   1. Adjustable strut-based support stands shall only be used as intermediate support points between permanent fixed stands/supports as required to prevent pipe from sagging.
   2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
   3. Base: Two or more, vulcanized rubber, molded polypropylene, or polycarbonate.
   4. Vertical Members: Two or more, galvanized or stainless steel, channels.
   5. Horizontal Member: Two or more, adjustable height, galvanized or stainless-steel pipe support slotted channels or plates.
   6. Pipe Supports: Roller, strut clamps, clevis hanger or swivel hanger.
   7. Hardware: Galvanized or stainless steel.
   8. Manufacturers: Dura-Blok, Roof Products Systems, nVent CADDY Pyramid, Portable Pipe Hangers, or equal.
   9. Accessories: Mount on protective roof pad with a minimum of 6" material extending beyond all edges to allow for future pipe movement. Nonwoven pad shall be constructed of spaghetti-like strands of flexible plastic with UV inhibitor and rated for -40°F to 180°F (-40°C to +82°C). Manufacturer: Yellow Spaghetti or equal.

E. Curb and Rail-Mounted Type Pipe Stands:
   1. Shop- or field-fabricated pipe supports made from structural-steel shapes, channels, continuous-thread rods, with rollers, strut clamps, clevis hangers or swivel hangers for mounting on permanent stationary roof curbs.
   2. Coordinate with structural design and mechanical details for attachment through membrane.

3. Manufacturer: Pate, Thybar, ThyCurb, Roof Products Systems, Protech, FastCurbs, or equal.

2.5 EQUIPMENT/PIPING RAILS

A. Where equipment/pipe rails are not provided by other sections of Specification, provide prefabricated reinforced equipment rails as required for support of equipment and piping. Field built curbs are acceptable alternatives - provide detail of construction for review.

B. Standard equipment rail, unless otherwise noted, shall be constructed as follows:
1. Construct of heavy gauge galvanized steel with continuous welds on shell seams.
2. Provide internal reinforcing supports welded as required to meet application requirements.
3. Equipment rails to have raised 3" (minimum), 45° cant.
4. Equipment rails to have 1-1/2" x 1-1/2" wood nailer (minimum) and counterflashing.
5. Equipment rail height to be 6" (minimum) above roof deck.
6. Cant shall be raised to match roof insulation thickness.

C. Equipment rails to be constructed to meet equipment size and weight requirements. Provide tapered rails to match roof pitch where required. Coordinate with structural design and mechanical details for attachment through membrane.

D. Manufacturer: Pate, Thybar, ThyCurb, Roof Products Systems, or equal.

2.6 ACCESS DOORS FOR WALL AND CEILING APPLICATIONS

A. Provide all access doors and panels to service equipment under this work, including those which must be installed, in finished architectural surfaces. Refer to other specification sections for specific access doors associated with ductwork and equipment.

B. Construction:
1. Frame: 16-gauge steel (minimum).
2. Door: 16-gauge steel (minimum) or two layers of 20-gauge steel (minimum) for double wall door construction.
3. Hinge: 1" flange width, continuous piano hinge.
4. Latching System: screwdriver latch, allen key latch or T-handle latch for non-public access areas. Cylinder key lock for public access areas. Cam latch for access to fire/life safety systems.
5. Paint: white prime coated.

C. Size:
1. Access doors shall be of a size to permit access and removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each trap primer, concealed valve, fire and combination fire/smoke dampers, volume dampers, and other equipment requiring access. Use no panel smaller than 12" x 12" for simple manual access, or smaller than 24" x 24" where personnel must pass through.

D. Architectural Coordination:
1. Refer to Division 01 Architectural specifications and drawings for additional requirements for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels are not shown on Plans.
2. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to service equipment under this work and in the proper sequence to coordinate with construction schedule and with prior approval of the Owner’s Representative.
3. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.
4. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner’s Representative.

E. Manufacturers: Milcor, Karp, Nystrom, Elmdor/Stoneman, or equal.

2.7 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 23 Sections. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category. Stencils, hand printed, painted, and felt pen markers are not acceptable.

B. Plastic Pipe Markers:
   1. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially or fully cover the circumference of pipe, or insulated pipe, and to attach to pipe without fasteners or adhesive complying with ANSI A13.1. Minimum letter size shall be 1/2” high.
   2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape.
   3. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.
   4. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
   5. Nomenclature shall include service type and directional arrow as follows:
      a. Chilled Water Supply and Return: green background with white lettering.
      b. Heating Water Supply and Return: yellow background with black lettering.
      c. Condenser Water Supply and Return: green background with white lettering.
      d. Heat Pump Loop Supply and Return: green background with white lettering.
      e. Refrigerant: yellow background with black lettering.
      f. Exhaust air: blue background with white lettering.
      g. Other piping services: Comply with ANSI and ASME A13.1standards.
      h. Direction of water flow.

C. Plastic Duct Markers:
   1. Provide duct labels to indicate the system and direction of flow. Submit a labeling product that is suitable for the surface to be labeled.
      a. Pressure sensitive, 16” long by 2-1/4” high (minimum), 3 mil thick high gloss adhesive backed vinyl, 1-1/2” high letters, and color coded per ducted service.
   2. Nomenclature shall include service type and directional arrow as follows:
      a. Supply air (cold service): green background with white lettering.
      b. Supply air (hot service): yellow background with black lettering.
      c. Return air: blue background with white lettering.
      d. Relief air: blue background with white lettering.
      e. Outside air: blue background with white lettering.
      f. Exhaust air: blue background with white lettering.
      g. Other air services: Comply with ANSI and ASME A13.1standards.
      h. Direction of air flow.

D. Valve Tags:
   1. Brass Valve Tags: Provide 1-1/2" diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener. Fill tag engraving with black enamel.
   2. Plastic Laminate Valve Tags (indoors only): Provide 3/32” thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32” hole for fasteners.
   3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves and manufactured specifically for that purpose.

E. Access Panel Markers: Provide 1/16" thick (minimum) engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve or device.

F. Plastic Equipment Signs:
   1. Provide 4-1/2” x 6” (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering. Minimum letter size shall be 1/2” high.
   2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
   3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
      a. Tag number
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters, such as pressure drop, entering and leaving conditions, rpm, etc.
   4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2”x11” bond paper, tabulate each equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

G. Underground-Type Plastic Line Markers: Provide 6" wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.

H. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Kolbi, or Brimar.

2.8 ACOUSTICAL BLANKET INSULATION

A. Application:
   1. Wrap high noise producing equipment and ductwork where occupied room noise levels cannot be obtained by architectural room barrier construction alone.
      a. Wrap variable air volume terminal where located above noise sensitive rooms such as conference rooms, lobbies and offices.
      b. Wrap ductwork where located above noise sensitive rooms such as conference rooms, lobbies and offices.
      c. Wrap fans where located above noise sensitive rooms such as conference rooms, lobbies and offices.
      d. Wrap chillers and pumps where located adjacent to noise sensitive rooms.

B. Manufacturers: Kinetics Noise Control #KNM-100ALQ, or equal by BRD Noise and Vibration Control, GLT Products #Vinaflex with Absorber/Decoupler, or Singer Safety Company, Quilted Fiberglass Panels.

C. Composite material, quilted, with reinforced aluminized-face, mass loaded limp vinyl bonded to scrim-face, quilted fiberglass absorber/decoupler.

D. The barrier shall be constructed of a 0.12” (3 mm), minimum, thick mass loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side. The barrier shall have a nominal density of 1.0 lbs./ft^2 (4.9-kg/m^2) and shall have a minimum STC rating of 28 as measured in an independent accredited acoustical laboratory in accordance with ASTM E90 and/or E413.

E. The decoupling layer shall be a combination of 1.0” (25 mm), minimum, fiberglass batting, non-woven porous scrim-coated glass cloth, quilted together in a matrix of 4” (100 mm) diamond stitch pattern which encapsulates the glass fibers.

F. The composite material shall be fabricated to include a minimum 2” (50 mm) wide barrier overlap tab extending beyond the quilted fiberglass to facilitate a leak-tight seal around field joints.

G. The barrier shall have a Flame Spread Index of no more than 10 and a Smoke Development Index of no more than 40 when tested for Surface Burning Characteristic per ASTM E84.

2.9 ELECTRICAL

A. General:
1. All electrical material, equipment, and apparatus specified herein shall conform to the requirements of Division 26.
2. Provide all motors for equipment specified herein. Provide motor starters, controllers, and other electrical apparatus and wiring which are required for the operation of the equipment specified herein.
3. Set and align all motors and drives in equipment specified herein.
4. Provide expanded metal or solid sheet metal guards on all V-belt drives to totally enclose the drive on all sides. Provide holes for tachometer readings. Support guards separately from rotating equipment.
5. Provide for all rotating shafts, couplings, etc., a solid sheet metal, inverted “U” cover over the entire length of the exposed shaft and support separately from rotating equipment. Cover shall extend to below the bottom of the shaft and coupling, and shall meet the requirements of the State Industrial Safety Regulations.
6. Specific electrical requirements (i.e., horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

B. Quality Assurance:
1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for location and use - no exceptions.

C. Motors:
1. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment Specifications.
2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Unless otherwise noted on plans, all motors 3/4 HP and larger shall be rated for 3-phase operation above 200 volts. Unless otherwise noted on plans, all motors up to 1/2 HP shall be rated for 120-volt, single phase operation.
4. Temperature Rating: Motor meets class B rise with class F insulation.
5. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
6. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design “B”, except “C” where required for high starting torque.
   a. Frames: NEMA Standard No. 48 or 56; use driven equipment manufacturer's standards to suit specific application.
   b. VFD driven motors to be provided as inverter ready and equipped with a shaft grounding device.
   c. Bearings:
      1) Ball or roller bearings with inner and outer shaft seals.
      2) Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
      3) Designed to resist thrust loading where belt drives or other drives product lateral or axial thrust in motor.
      4) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
      5) Enclosure Type:
         a) Open drip-proof (ODP) motors for indoor use in clean air environments.
         b) Totally enclosed fan cooled (TEFC) motors for outdoor use and indoor application in dirty environments.

c) Totally enclosed air over (TEAO) motors for motors in the airstream of cooling towers and fluid coolers.
d) Guarded drip-proof motors where exposed to contact by employees or building occupants.
e) Weather protected Type I for outdoor use, Type II where not housed.

d. Overload Protection: Built-in thermal overload protection where external overload protection is not provided and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
e. Noise Rating: “Quiet.”
f. Efficiency:
1) Motors shall have a minimum efficiency per governing State or Federal codes, whichever is higher.
2) And, motors shall meet the NEMA premium efficiency standard.
g. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

D. Starters and Electrical Devices:
1. Motor Starter Characteristics:
a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs.
b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
2. Manual switches shall have pilot lights and all required switch positions for multi-speed motors. Overload Protection: Melting alloy or bi-metallic type thermal overload relays, sized according to actual operating current (field measured).
3. Magnetic Starters:
a. Heavy duty, oil resistant, hand-off-auto (HOA), or as indicated, and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
b. Trip-free thermal overload relays, each phase, sized according to actual operating current (field measured).
c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division 23 Controls sections.
d. Built-in primary and secondary fused control circuit transformer, supplied from load side of equipment disconnect.
e. Externally operated manual reset.
f. Under-voltage release or protection for all motors over 20 hp.
4. Motor Connections: Liquid tight, flexible conduit, except where plug-in electrical cords are specifically indicated.

E. Low Voltage Control Wiring:
1. General: 14-gauge, Type THHN, color coded, installed in conduit.
2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp., Senator Wire and Cable Co., or Southwire Co.

F. Disconnect Switches:
1. Fusible Switches: For equipment 1/2 HP or larger, provide fused, each phase; heavy duty; horsepower rated; spring loaded quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the “OPEN” position; arc quenchers; capacity and characteristics as indicated.
2. Non-Fusible Switches: For equipment less than 1/2 horsepower, switch shall be horsepower rated; toggle switch type with thermal overload quantity of poles and voltage rating as required.

PART 3 - EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work unless so indicated on Drawings or approved by Owner's Representative.

3.2 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers' directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

1. If the contractor must deviate from the manufacturer's recommendations provide a letter from the manufacturer indicating the clearance to be provided is acceptable for scheduled performance and maintenance.

3.3 INSTALLATION

A. Coordinate the work between the various Mechanical Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision or failure to make proper and timely provisions, the alternations shall be made to the satisfaction of the Engineer and at the Contractor's cost. Coordinate wall and ceiling work with the General Contractor, and other trades in locating ceiling air outlets, wall registers, etc.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defected materials.

3.4 SUPPORTS AND HANGERS

A. Prior to installation of hangers, supports, anchors, and associated work, installer shall meet at project site with the General Contractor, installer of each component of associated work, inspection and testing agency representatives, (if any), installers of other work with requirements specified.

B. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms. Where Gypcrete is indicated, install reinforcing bars through opening at top of inserts. Inserts and anchors shall be located no closer than 6" to any edge and no closer than 1" from any pre-tension cables or embedded steel and as required per manufacturer's instructions and Structural Engineer.

C. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

D. Install hangers, supports, rails, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers and rails where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

E. Install pipe supports (hangers, rails, etc.) within 12 inches of every change in piping direction (only one support required at each change in direction), end of pipe run or concentrated load, and within 36 inches of every major piece of equipment. Supports (hangers, rails, etc.) shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one support is required.

F. Install hangers, rails, and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

G. Support sprinkler piping and gas independently of other piping.

H. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

I. Hanger Spacing in accordance with following minimum spans for support of individual pipes and a minimum of one hanger per elbow at each change of direction. For straight runs of horizontal piping with no concentrated loads such as valves, flanges, expansion joints, or other components. Sections of piping with concentrated loads will have to be considered carefully and a determination made as to appropriate spacing and rod size for the given situation. Other spacing and rod sizes may be considered in compliance with Table 121.5 of ASME B31.1, ANSI/MSS SP-58 Table 4, and local mechanical code, but shall not exceed 12 feet for any pipe size. Comply with more restrictive requirements of local codes where those exceed the following minimum criteria.

1. Steel Pipe:

Steel Pipe Size	Hanger/Support Spacing (Maximum)	Rod Size (Minimum)
1/2" to 1”	7 feet	3/8”
1-1/4” to 2-1/2”	10 feet	3/8”
3” to 4”	12 feet	3/8”
5” to 8”	12 feet	1/2"
10” to 12”	12 feet	5/8”
14” to 16”	12 feet	3/4"

2. Copper Pipe:

Copper Pipe Size	Hanger/Support Spacing (Maximum)	Rod Size (Minimum)
1/2"	4 feet	3/8”
3/4” to 2”	6 feet	3/8”
2-1/2” to 4”	8 feet	3/8”
5” to 8”	8 feet	1/2"

3. Plastic/Fiberglass Pipe:

Plastic/Fiberglass Pipe Size	Hanger/Support Spacing (Maximum)	Rod Size (Minimum)
Up to 1”	3 feet	3/8”
1-1/4” to 2-1/2”	4 feet	3/8”
3” to 8”	5 feet	1/2"

4. Trapeze support: Provide details stamped by a Registered Structural Engineer for the project state indicating trapeze channels, support rod sizes, and spacing.

5. Maximum threaded rod loading: Below are maximum loads for hanger rods based on ASHRAE Handbook and ASTM A36, with a safety factor of 5.

Nominal Rod Diameter	Load (Maximum Weight)
3/8”	610 pounds
1/2"	1,130 pounds
5/8”	1,810 pounds
3/4"	2,710 pounds
7/8”	3,770 pounds
1”	4,960 pounds

J. Provisions for Movement:
1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.
3. Insulated Piping: Comply with the following installation requirements:
   a. Clamps: Attach clamps, including spacers, (if any), to piping with clamps projecting through insulation.
   b. Shields: Where low compressive strength insulation or vapor barriers are indicated on cold or chilled water piping, install shields or inserts.
   c. Saddles: Where insulation without vapor barrier is indicated install protection saddles.

K. Installation of Anchors:
1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs and at intermediate points in pipe runs between expansion loops and bends.

L. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

M. Equipment Supports:
1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction. Coordinate size of concrete pads and placement of anchors bolts with structural design. Anchor bolts shall be placed to maintain 6", minimum, or greater distance from concrete pad edges.
2. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.

N. Adjusting:
1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

O. Upper Building Attachments: Powder-actuated fasteners may be used where appropriate for construction materials to which hangers are being attached per the following:
1. Maximum allowable tension load shall not exceed 50 lbs. (0.2 kN) per attachment.
2. May only by used to supporting for ductwork up to two (2) square feet (0.2 m^2) in cross sectional area and for control conduit clips.
3. May not be used for support of any piping, equipment, or ductwork greater than two (2) square feet (0.2 m^2) in cross sectional area.
4. Use concrete inserts before placing concrete in new construction.
5. Install powder-actuated concrete fasteners after concrete is placed and completely cured to concrete compressive strength of 4000 psi or greater.
6. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
7. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
8. Do not use powder-actuated concrete fasteners for seismic restraints.

3.5 WALL, FLOOR, AND ROOF PENETRATIONS

A. All pipe and duct penetrations through rated and non-rated assemblies shall be sized to allow for compliance with structural integrity and fire ratings, as applicable. Penetrations of fire-resistance-rated assemblies shall be protected by an approved firestop system installed and tested in accordance with ASTM E814 or UL 1479. The system shall have an F rating/T rating of not less than the required rating of the floor or wall penetrated. Where sleeves are required, the sleeve size shall be installed with the inside clear diameter providing clearances as required below. Coordinate the required opening sizes with the manufacturer of the fire protection products.
1. Uninsulated pipe penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1" (minimum) to 2" (maximum) larger than the outside diameter of each uninsulated pipe.
2. Insulated pipes penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1" (minimum) to 2" (maximum) larger than the outside diameter of each pipe, including insulation.
3. Uninsulated pipe penetrations through fire rated walls and floors, and through roof: penetration sizes shall be a 1/2" (minimum) to 1-1/2" (maximum) larger than the outside diameter of each uninsulated pipe to provide minimum 1/4" annular space between the outside of the pipe surface and assembly. Coordinate with specific manufacturer requirements and UL listing.

4. Insulated pipe penetrations through fire rated walls and floors, and through roof: pipe penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each insulated pipe to provide minimum 1/4” annular space between the outside of the insulation surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
5. Uninsulated pipe penetrations through foundation and basement walls: penetration sizes shall be larger than the outside diameter of each uninsulated pipe to allow adequate space for installation of mechanical link seals. Coordinate with specific manufacturer requirements.

3.6 ROOF CURBS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed, as applicable.

C. Verify roof insulation thickness and adjust height of perimeter cant strips to accommodate insulation and roofing material installation.

D. Provide rigid insulation, minimum 1” thick, on exposed elements of roof curb.

E. Provide additional rigid insulation inside the roof curb perimeter secured to roof surface, around ductwork penetrations, to match the adjacent roof insulation levels (same R-value or greater).

3.7 EQUIPMENT RAILS AND PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed, as applicable.

C. Verify roof insulation thickness and adjust height of perimeter cant strips to accommodate insulation and roofing material installation.

3.8 ELECTRICAL COORDINATION

A. Division 23 installers shall coordinate with Division 26 work to provide complete systems as required to operate all mechanical devices installed under this Division of work.

B. Installation of Electrical Connections: Furnish, install, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, etc., motors and controls in accordance with the drawings and in accordance with equipment manufacturer’s written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC, and NECA’s “Standard of Installation” to ensure that products fulfill requirements.

C. Division 23 has responsibilities for electrically powered mechanical equipment which is specified in Division 23 Specifications or scheduled on Division 23 Drawings as follows:
1. Motors: Furnish and install all motors necessary for mechanical equipment.
2. Magnetic Starters: Furnish all magnetic starters whether manually or automatically controlled which are necessary for mechanical equipment. Furnish these starters with all control relays or transformers necessary to interface with mechanical controls. If the starter is factory installed on a piece of Division 23 equipment, also furnish and install the power wiring between starter and motor.
3. Variable Frequency Drives: Provide all VFD’s associated with mechanical equipment. If the drive is installed on a piece of factory assembled equipment the wiring between motor and drive is to be provided as part of the factory equipment.
4. Disconnects: Provide the disconnects which are part of factory wired Division 23 equipment. Factory wiring to include wiring between motor and disconnect or combination starter/disconnect.

5. Controls: Division 23 Contractor (including the Building Automation System (BAS) Controls subcontractor) is responsible for furnishing the following equipment in its entirety. This equipment includes but is not limited to the following:
   a. Additional control panels beyond what is identified on drawings shall be provided by BAS contractor in order to provide a complete control system at no additional cost to Owner.
   b. Control relays necessary for controlling Division 23 equipment.
   c. Control transformers necessary for providing power to controls for Division 23 equipment.
   d. Line voltage thermostats.
   e. Low or non-load voltage control components.
   f. Remote bulb thermostats.
   g. Non-life safety related valve or damper actuators.
   h. Float switches.
   i. Solenoid valves.
   j. Switches.
   k. Refrigeration controls.
   l. Communications wiring and conduit between control devices and mechanical equipment. Control wiring gauge in stranded or solid wire configuration shall be the responsibility of the contractor to coordinate with manufacturers for allowable lengths and load requirements to assure complete and operational systems.
   m. Raceway to support control cabling.
6. Fire/Smoke Dampers: Division 23 is responsible for providing and physically installing the damper and for installing any required control interface wiring to Division 23 controls.
   a. Where fire/smoke dampers are part of an integrated smoke control system, Division 23 is responsible for providing dampers with necessary end switches for use by Division 28 in providing proof of closure.
   b. Where these dampers are not part of an integrated area wide smoke detection system, Division 23 is responsible for providing each fire/smoke damper with a dedicated duct detector installed per the requirements of the building code. If not integral with the damper assembly, the detector is to be installed in ductwork by Division 23 but wired to the damper controller by Division 26.

D. Division 26 Electrical Responsibilities:
1. BAS Controls Contractor shall initiate and coordinate a meeting with the Electrical Contractor and General Contractor to coordinate all BAS component locations and wiring requirements prior to start of construction. All additional costs associated with lack a coordinated shall be the responsibility of the BAS Contractor at no additional cost to the Owner.
2. Additional power requirements, including conduit and wiring, for additional or relocated control panels and devices shall be coordinated and the responsibility of the BAS Controls Contractor at no additional cost to Owner.
3. Motors: Provide the power wiring for the motors from servicing panel to motor controller.
4. Magnetic Starters: Except where magnetic starters are factory installed on Division 23 factory assembled equipment, Division 26 is to install magnetic starters furnished by Division 23 and install the necessary power wiring to the starter and from the starter to the motor. In the case of factory installed starters, Division 26 is to install the necessary power wiring from source panel/disconnect to the starter.
5. Variable Frequency Drives: Provide the necessary power wiring to the VFD and from the VFD to the motor except in the case of factory installed VFD’s where wiring between the motor and VFD is to be by Division 23.
6. Disconnects: Provide all disconnects necessary for Division 23 mechanical equipment which are not provided as part of factory wired Division 23 equipment. Provide power wiring to all disconnects. In addition, provide power wiring between motor and disconnect when the disconnect is not factory installed.

7. Controls: Division 26 is responsible for providing power to mechanical control panels and provide final power connection to Division 23 provided control transformers.
8. Fire/Smoke Dampers: Division 26 is responsible for power wiring to each damper and as follows:
    a. Where these dampers are part of an integrated smoke control system Division 28 is responsible for providing the detectors and for all fire/smoke detection system wiring necessary to integrate dampers and related end switches into the system.
    b. Where these dampers are not part of an integrated area wide smoke detection system, Division 23 is responsible for providing each fire/smoke damper with a dedicated duct smoke detector installed per the requirements of the building code. If not integral with the damper assembly, the detector is to be installed by Division 23, but wired for damper control by Division 26.

E. Motors and Motor Control Equipment: Conform to the standards of the NEMA. Equip motors with magnetic or manual line starters with overload protection. Motor starters and line voltage controls shall be installed under Electrical Section but located and coordinated as required under this Section of the work. Starters shall be combination type with non-fusible disconnect switches. All single phase fractional horsepower motors shall have built-in overload protection.

3.9 FIELD PAINTING

A. All painting shall be provided under this Division work, unless otherwise specified under Section 099100: Painting. Painting schemes shall comply with ANSI A13.1. Paint all exposed materials such as piping, ductwork, equipment, insulation, steel, etc. The inside surface of visible ductwork above diffusers/grilles shall be painted flat black.

B. All exposed work under Division 23 shall receive either a factory finish or a field prime coat finish, except:
1. Exposed copper piping.
2. Aluminum jacketed outdoor insulated piping.

3.10 FACTORY PAINTING

A. Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120°F (50°C), the factory painting system must be designed for the temperature service.

3.11 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Piping System Identification:
1. Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.
2. Locate pipe markers as follows:

a. Near each valve and control device.
b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
c. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
d. At access doors, manholes, and similar access points which permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.
f. Spaced horizontally at maximum spacing of 20' along each piping run, with minimum of one in each room.
g. Vertically spaced at each story transversed.

C. Ductwork Identification: A minimum of every 50' for all ductwork, 12" or more in diameter or width, where ducts are concealed above accessible ceilings.

D. Mechanical Equipment Identification: Locate engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device. Provide signs for the following:
1. Main control and operating valves, including safety devices.
2. Meters, gauges, thermometers, and similar units.
3. Fans.
4. Balancing dampers and mixing boxes.
5. Packaged HVAC central-station and zone-type units.
6. Tanks and pressure vessels.
7. Strainers, filters, treatment systems and similar equipment.

E. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.

F. Underground Piping Identification: During backfilling/topsoiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker.

3.12 VIBRATION AND DYNAMIC BALANCING

A. All equipment submitted and installed by Division 23 shall not exceed maximum tolerances as specified by the “International Research and Development Corporation”, Worthington, Ohio, measured by the displacement, peak to peak, as follows:
1. All Fans: Below severity chart labeled “FAIR”, maximum velocity of 0.0786 in/sec, peak.
2. Pump and Electric Motors: Below severity chart labeled “SLIGHTLY ROUGH”, maximum vibration velocity of 0.157 in/sec, peak.
3. Compressors: Same as pumps.

B. Where installed equipment noise or vibration is objectionable to the Owner’s Representative, it shall be responsibility of the contractor to conduct testing to confirm that the equipment does not exceed the standard.

C. Correction shall be made to all equipment, which exceeds vibration tolerances specified above. Final vibration levels shall be reported as described above.

3.13 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner’s

Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Ductwork: Test all air quantities as specified in Section 230593 - Testing, Adjusting and Balancing. Pressure tests per SMACNA.

C. Registers and Diffusers: Test for proper operation of manually operated control feature. Test all air quantities as specified in Section 230593 – Testing, Adjusting and Balancing.

D. Ductwork Specialties: Test all operable ductwork specialties for proper operation. Check all fire, smoke and fire/smoke dampers to ensure that they are 100% open.

E. Temperature Control: Test all control functions to assure that all systems are controlling as specified or as otherwise necessary and that all controls are adjusted to maintain proper room temperatures. The manufacturer's representative shall perform all tests.

END OF SECTION 230500

SECTION 230530

DUCT AND COIL CLEANING

PART 1 - GENERAL

1.1 SCOPE

A. Clean the inside surface of all ductwork and plenums.

B. Clean all evaporator and condenser coils.

C. Clean all condensate pans.

D. Clean all fan blades and assemblies.

E. Clean all dampers, motors and linkages.

1.2 MAINTAINING EXISTING SERVICES

A. The existing heating, ventilating and air conditioning system shall be maintained to all occupied areas during the normal working week. Any exceptions to this rule must be arranged thru the Owner beforehand.

1.3 PROPER EQUIPMENT

A. The Contractor shall provide the power vacuum operating at a minimum of 16,000 cfm at 21" wc; 25 CFM air compressor operating at 210 psi; electric power vent cleaner and reverse jet air flow nozzle, all staging, scaffold, ladders or similar equipment required to properly carry on the work. Suitable protective covering shall be provided by the Contractor in all areas of work operation. Any mechanical defects to be reported to all person/persons in charge.

1.4 EXPERIENCED SUPERVISION

A. All work shall be supervised by a Foreman having thorough knowledge and experienced in the cleaning of heating and air conditioning systems. The work shall be performed by experienced, qualified personnel. Contractor shall be responsible to coordinate with the Owner's Representative. This will insure that both parties are fully aware of work to be performed and time perimeters that work will be completed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials specified by brand names used for the work described herein shall be delivered to the job site in original, un-opened, clean containers with labels in place. All such materials shall be of the brand and type specified. Substitution of any materials will not be permitted, unless pre-qualified and approved by the Owner's Representative.

2.2 GASKETING

A. Gasketing shall be a polyethylene foam, self adhering type with a minimum width of 1/4".

2.3 FIBERGLASS INSULATION MATERIAL

A. Fiberglass insulation material to be repaired will be of equal quality and thickness as contained in equipment requiring repair. Fiberglass will be sealed together by means of wall tacks, lagging tape lagging adhesive and lagging coating. Materials used will be of the highest quality (ie: Foster White, Foster Coating: respectively).

PART 3 - EXECUTION

3.1 STORAGE OF CONTRACTOR'S EQUIPMENT AND MATERIALS

A. The contractor shall remove all materials from job site daily. Owner shall not be responsible for loss, theft or damage of any materials, equipment or devices provided by the Contractor while used on Owner's property.

3.2 CLEAN-UP

A. Contractor shall, at the end of each shift, remove all waste, dirt and debris, resulting from the work performed. Such material shall be removed from the property and disposed of at the Contractor's expense, unless pre-qualified and approved by the Owner's Representative.

3.3 ACCESS OPENINGS AND DOORS

A. Access will be cut into duct for proper cleaning. Sheet metal panels with proper caulking and of the same or heavier gauge metal shall be installed when the ducts are cleaned.

3.4 CAULKING

A. Caulking shall be performed in a neat and effective manner. No caulking shall be applied over surfaces which contain dirt, rust, oil, scale, deteriorated caulking or other foreign matter which would affect adhesion. All caulking shall be Loctite Super Flex Caulking Compound or equivalent, as approved by the Owner's Representative.

3.5 COILS - (HEATING AND COOLING)

A. Cleaning will consist of high power wash downstream of coil first and then upstream of coil. A detergent solution specifically designed for this purpose will be used in washing. Process will be repeated until coils have been rendered clean.

B. High power wash will be performed with a water spray device that delivers a minimum of 500 psi. Detergent cleaning shall be followed by a thorough rinsing with fresh water.

C. A degreasing solution shall be used in areas required, (i.e. oil, grease, rubber or adhesive) build-up of the coils. Any degreasing of coils shall be performed before final cleaning of coils to insure complete removal of any residual build-up.

D. Drain pans are to be cleaned and cleared before and after any pressure washing is performed, thus assuring complete and safe drainage.

3.6 PLENUM AREAS

A. All interior walls, ceilings and floors shall be power vacuumed. Plenum areas shall be inspected and sealed air tight with approved caulking compound.

B. Fiberglass insulating material found to be in need of repair will be repaired or replaced and properly bonded with adhesive, clips and proper lagging material.

C. Fiberglass material shall be sealed with Quaker Koat after it has been thoroughly hand vacuumed to insure proper adhesion.

3.7 FANS AND FAN HOUSING

A. Fan and fan assemblies shall be thoroughly cleaned by Power Vacuuming and high-pressure washing. Degreasing, scraping and wire brushing will be performed where required.

3.8 FILTERS

A. New filters shall be installed when unit has been completely cleaned. Filters shall be provided by the Owner.

3.9 DAMPERS, MOTORS AND LINKAGE

A. Dampers will be inspected and repaired.

B. Repairs will include straightening and aligning of blades and linkage.

C. All related equipment will be power vacuumed and high pressure washed where required.

D. Areas with rust or scale build-up will be wire brushed or scraped.

E. All damper motors and linkage will be lubricated and set into their original position upon completion of work in plenum areas.

F. All ducts shall be thoroughly cleaned by power vacuuming. Ductwork that does not allow complete access shall be entered by means of access holes.

G. All ducts will be cleaned, and inspected, as work proceeds. Any major repairs will be brought to the attention of the Owner's Representative.

H. Minor repairs (ie: caulking, sealing, reconnecting) of ductwork will be performed in the normal manner of the contractor's work.

3.10 DAMAGE BY DIRT OR DUST

A. The Contractor shall be responsible for all damage to any part of the Owner's premises, equipment or machinery due to dirt or dust attributed to the negligence of his work. The Contractor shall clean, repair or replace such damages at no expense to the Owner.

3.11 CLOSING IN OF UNINSPECTED WORK

A. Contractor shall not allow or cause any of the work to be covered up or enclosed until it has been inspected and approved by an authorized person. Should any of his work be covered up or enclosed before such inspection, he shall, at his own expense, uncover the work, and after it has been inspected and approved, make all repairs with such materials as may be necessary to restore all his work to its original and proper conditions.

END OF SECTION 230530

SECTION 230548

VIBRATION ISOLATION FOR PIPING, DUCTWORK, AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

B. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All mechanical equipment, piping and ductwork as noted on the equipment schedule, in the specification or as required by code shall be designed to resist seismic forces. Refer to Section 230549 Seismic Restraint for Piping, Ductwork and Equipment

D. This Section includes the following:
1. Vibration isolation curbs, pads and mounts.
2. Flexible ductwork connectors
3. Spring hangers with and without vertical-limit stops.
4. Spring isolators.
5. Restrained uni-directional seismic isolation snubber mounts.
6. Housed seismic spring vibration mounts.
7. Elastomeric hangers.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Air-mounting system.
11. Restrained vibration isolation roof-curb rails.
12. Seismic snubbers.
13. Vibration isolation equipment bases.
14. Flexible piping connectors

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230549: Seismic Restraint for Piping, Ductwork and Equipment.

1.3 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. IBC: International Building Code with State Amendments.

C. ICC-ES: ICC-Evaluation Service.

1.4 CODES AND STANDARDS

A. Provide components conforming to the load requirements of the latest addition of the local building code and the following:
1. International Building Code with AHJ Amendments
2. American Society of Civil Engineers (ASCE):
   a. ASCE 7 (Latest Edition): Minimum Design Loads for Buildings and Other Structures.
3. The Manufacturers Standardization Society (MSS):

a. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
b. MSS SP-69: Pipe Hangers and Supports - Selection and Application.
c. MSS SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices
d. MSS SP-127: Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application.

4. Mason West Inc. Seismic Restraint Guidelines 2014 Edition
   a. For all suspended piping, suspended ductwork and suspended electrical raceways.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Refer to Section 230549 Seismic Restraint for Piping, Ductwork and Equipment for seismic specific requirements.
   2. Vibration isolators must be rated for the seismic loading associated with the system and forces calculated for this building location. Seismic forces for new installations are determined per ASCE 7. Refer to Structural Design for seismic factors and design criteria. Select and submit appropriate values for each piece of equipment and sub-system and material type for the project, and base the seismic calculations on these values.
   3. Coordinate all seismic and load requirements with the registered professional Structural Engineer.

B. Component Importance Factor:
   1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.
   2. Ip=1.5: Components associated with Risk Category IV Buildings (Essential Services); or for conditions outlined in ASCE 7 Section 13.1.3 regardless of Risk Category; or Hospitals and Correctional Treatment Centers. Components include, but are not limited to the following:
      a. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
      b. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.

1.6 QUALITY ASSURANCE

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

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

C. Building Structural Limits: The design of supports and restraints shall not exceed the building structure allowable point loads. Coordinate all work with the registered professional Structural Engineer.

D. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

1.7 WARRANTY

A. Provide minimum one-year warranty requirements, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

1.8 SUBMITTALS

A. Product Data shall include the following:
   1. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
   2. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
   3. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   4. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service or agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
   1. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
   2. Provide all details of suspension and support for ceiling hung equipment.
   3. Where walls, floors, slabs or supplementary steel work are used for seismic restraint the locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
   4. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

C. Manufacturer Design Submittal: For vibration isolation details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and where required wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads. Provide base with level top surfaces with integral sloping on bottom to match support structure.

D. Coordination Drawings: Show coordination and plan locations of vibration isolation for HVAC ductwork, piping, and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Qualification Data: Devices shall be selected to meet seismic and support requirements by a registered professional Structural Engineer.

F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent test agency.

G. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.9 WARRANTY

A. Refer to section 230500 for basic warranty requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS AND APPLICATION

A. Factory Finishes:
1. Standard paint applied to factory-assembled equipment before shipping.
2. Powder coating on springs and housings.
3. All hardware shall be galvanized or powder coated.
4. Hot-dip galvanized or powder coating of metal components for exterior use.
5. Baked enamel or powder coat for metal components for interior use.

B. Glumac Device Key Schedule: Part 3 of this Section schedules the application of devices described in Part 2 for use with mechanical equipment found on this project. The tag designation of preferred devices is as follows:

Glumac Isolator Tag	Description
P-1	Vibration isolation waffle pad
P-2	Double deflection neoprene mount
P-3	Uni-directional restrained neoprene snubber mount
P-4	Interlocking uni-directional snubber
S-1	Open spring vibration isolator
S-2	Steel housed seismic spring vibration isolator
S-3	Bellows air spring isolator
S-4	Restrained air spring isolator
C-1	Seismic spring isolation roof curb (20 ton HVAC and below)
C-2	Seismic spring isolation roof curb (Greater than 20 ton HVAC)
C-3	Curb mounted spring isolation roof base
B-1	Integral equipment and motor base
B-2	Integral equipment and motor base
B-3	Concrete filled steel inertia base
H-1	Spring and rubber in shear vibration isolation hanger
G-1	All-directional pipe anchor
G-2	Vertical pipe guide
G-3	Horizontal thrust restraint
SB-1	Sway bracing
F-1	Kevlar/rubber spherical type flexible piping coupling
F-2	Stainless hose flexible piping coupling
F-3	Flexible expansion joints
F-4	Flexible ductwork connector

2.2 VIBRATION ISOLATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:
1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)

3. California Dynamics Corporation.
4. Kinetics Noise Control.
5. Vibration Eliminator Co., Inc.
6. Vibration Isolation.
7. Vibration Mountings & Controls (VMC Group)
8. Vibro-Acoustics, Inc
9. Vibrex
10. VMC Group

B. P-1 Style: Neoprene pads shall consist of a 3/4" (19 mm) thick neoprene pad molded in square waffle modules, a minimum 1/4” (6 mm) thick steel load distribution plate and 3/4” (19 mm) hole with a neoprene anchor bolt bushing with a flat washer face. Pads may be single or multiple layers as required for leveling. Manufacturers: Mason #MBSW Series or equal.

C. P-2 Style: Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2" (5mm) and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Manufacturers: Mason #BR Series, VMC Group #YRSM3 Series, or equal.

D. P-3 Style: All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4” (6 mm) thick. A minimum air gap of 1/8” (3 mm) shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. No sharp edges such as bolt threads may come in contact with the neoprene bushing. Snubber end caps shall be removable to allow inspection of internal clearances. Manufacturers: Mason #Z-1225 Series or equal.

E. P-4 Style: All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specifications. Elastomeric materials shall be replaceable and a minimum of 3/4" (19 mm) thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" (3 mm) nor more that 1/4" (6 mm). Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8" (9 mm) deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to 1/2" (12 mm) deflection in the x, y and z planes. Manufacturers: Mason #Z-1011 Series or equal.

F. S-1 Style: Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" (6 mm) neoprene acoustical friction pad between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Two base plate holes for attachment to support surface. Manufacturers: Mason #SLFH Series or equal.

G. S-2 Style: Restrained spring mountings shall include springs that are free standing and laterally stable and complete with a molded neoprene cup or 1/4" (6 mm) neoprene acoustical friction pad between the spring and the mounting base plate. All spring assemblies shall have leveling bolts. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Mount housing shall include vertical limit stops to prevent spring extension when weight is removed. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical and horizontal directions. A minimum clearance of 3/8” (9 m) shall be maintained around restraining bolts so as not to interfere with the spring action. Manufacturers: #SLR Series or #SLRS Series for steel/wood

connections and Mason #SLREBP Series or #SLRSEBP Series or #SSLFH Series for concrete connections, or equal.

H. S-3 Style: Multiple bellow air springs shall be manufactured with powder coated upper and lower steel sections connected by a replaceable, flexible Nylon reinforced Neoprene element to achieve a maximum natural frequency of 3 Hz. Burst pressure must be a minimum of three (3) times the published maximum operating pressure. All air spring systems shall be equipped with three (3) leveling valves connected to the building control air or a supplementary air supply to maintain elevation plus or minus 1/8" (3 mm). An air filter and water separator shall be installed before the air distribution system to the leveling valves. Submittals shall include natural frequency, as well as load and damping tests, all as performed by an independent lab or acoustician. Manufacturers: Mason #MT and leveling valves Mason #LV, or equal.

I. S-4 Style: Restrained mountings shall include multiple bellow air springs manufactured with powder coated upper and lower steel sections connected by a replaceable, flexible Nylon reinforced Neoprene element to achieve a maximum natural frequency of 3 Hz. Burst pressure must be a minimum of three (3) times the published maximum operating pressure. Mount housing shall include vertical limit stops to prevent spring extension when weight is removed. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical and horizontal directions. A minimum clearance of 3/8” (9 mm) shall be maintained around restraining bolts so as not to interfere with the spring action. Mountings shall have test reports or calculations certifying the maximum allowable horizontal and vertical load ratings. All air spring systems shall be equipped with three (3) leveling valves connected to the building control air or a supplementary air supply to maintain elevation plus or minus 1/8" (3 mm). An air filter and water separator shall be installed before the air distribution system to the leveling valves. Submittals shall include natural frequency, as well as load and damping tests, all as performed by an independent lab or acoustician. Manufacturers: Mason #SLR-MT for steel connections and Mason #SLREBP for concrete connections and leveling valves Mason #LV, or equal.

2.3 SEISMIC RESTRAINED SPRING VIBRATION ISOLATION ROOF-CURB (C-1) (HVAC UNITS 20 TON AND UNDER CAPACITY)

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:
1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls (VMC Group)
10. Vibro-Acoustics, Inc.
11. VMC Group

B. C-1 Style: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. Curbs shall consist of continuous sheet metal frames above and below isolators. Isolators shall be adjustable, free-standing and laterally stable and include a 1/4” (6 mm) acoustical neoprene cup and leveling bolt. Spring diameters shall be no less than 0.8 of the compressed height of the spring at the rated load with 50% additional travel to solid. Seismic snubbers with an all directional neoprene bushing and 1/4” (6 mm) air gap shall be incorporated into each corner. A continuous sheet metal flashing shall be attached to the upper frame and be separated from the lower frame by a neoprene weatherseal. The sheet metal flashing shall incorporate removable cover plates for adjustment and inspection of isolators after the unit is set. The unit must be solidly fastened to the top steel frame

and the lower sheet metal curb must be attached to the roof structure. Manufacturers: Mason #ISC Series or equal.

C. C-3 Style: Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the rigid roof curb and under the isolated equipment. The extruded aluminum top member shall overlap the bottom to provide water runoff independent of the seal. Aluminum members shall house electro-galvanized or powder coated springs selected for 0.75” (20 mm) minimum deflection. Travel to solid shall be 1.5” (40 mm) minimum. Spring diameters shall be no less than 0.8 of the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4” (6 mm) so as not to interfere with the spring action except in high winds. Manufacturer’s self adhering closed cell sponge gasketing must be used both above and below the base and a flexible EPDM duct like connection shall seal the outside perimeter. Foam or other sliding or shear seals are unacceptable in lieu of the EPDM ductlike closure. Submittals shall include spring deflections, spring diameters, compressed spring height and solid spring height as well as seal and wind resistance details. Manufacturers: Mason #CMAB Series or equal.

2.4 SEISMIC RESTRAINED SPRING VIBRATION ISOLATION ROOF-CURB (C-2) (HVAC UNITS OVER 20 TON CAPACITY)

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:
1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls (VMC Group)
10. Vibro-Acoustics, Inc.
11. VMC Group

B. C-2 Style: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of 1/4" (6 mm) thick. Steel springs shall be laterally stable and rest on 1/4" (6 mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" (50 mm) of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Manufacturers: Mason #RSC Series or equal.

2.5 VIBRATION ISOLATION STEEL EQUIPMENT BASES

A. Basis-of-Design Product: Subject to compliance with requirements provide a comparable product by one of the following:
1. Mason, basis of selection or equal by
2. Amber/Booth Company (VMC Group)
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Vibration Eliminator Co., Inc.

7. Vibration Isolation.
8. Vibration Mountings & Controls (VMC Group)
9. Vibro-Acoustics, Inc.
10. VMC Group

B. B-1 Style: Vibration isolation manufacturer shall furnish integral structural steel bases designed to prevent excessive base flexure at start up, prevent misalignment of equipment and provide attachment points for seismic restraints. Bases shall be rectangular in shape and constructed of welded structural steel angle or channel members. Manufacturers: Mason #MSL Series or equal.

C. B-2 Style: Vibration isolation manufacturer shall furnish integral structural steel bases designed to prevent excessive base flexure at start up, prevent misalignment of equipment and provide attachment points for seismic restraints. Bases shall be rectangular in shape and constructed of welded wide flange structural steel main members with cross bracing located at or near each restraint location. Where height saving brackets are required, they shall be employed in all mounting locations to maintain a 1" (25 mm) clearance below the base. Manufacturers: Mason #WFSL Series or #TSLR Series, or equal.

D. B-3 Style: Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows and shall be 6” deep for pumps through 75 hp and 10” deep for pumps 100 hp through 250 hp. Forms shall include minimum concrete reinforcing consisting of #4 bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Manufacturers: Mason #BMK Series or #KSL Series or equal.

2.6 SPRING HANGERS

A. H-1 Style: Spring hangers shall consist of rigid steel frames containing minimum 1-1/4” (32 mm) thick neoprene elements at the top and steel springs that are free standing and laterally stable seated in a steel washer reinforced neoprene cup at the bottom. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. The neoprene element and the cup shall have a neoprene bushing projecting through the steel box. A seismic rebound washer made of steel and surrounding neoprene shall be provided. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Manufacturers: Mason #RW30N Series or equal.

2.7 PIPE GUIDES AND SUPPORTS

A. G-1 Style: All-directional acoustical pipe anchors shall consist of two sizes of steel tubing separated by a minimum 1/2" (12 mm) thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. Manufacturers: Mason #ADA Series or equal.

B. G-2 Style: Vertical sliding pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" (20 mm) thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of 1-5/8" (41 mm) upwards or downwards motion, or to meet location requirements. Manufacturers: Mason #VSG Series or equal.

C. G-3 Style: Horizontal thrust restraints shall consist of a spring element seated in a steel washer reinforced neoprene cup at the bottom, in series with a molded neoprene element. Steel springs shall be free standing and laterally stable. Spring diameters shall be no less than 0.8 of the

compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" (6 mm) movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Manufacturers: Mason #WBI Series or #WBD Series or equal.

2.8 SWAY BRACING

A. SB-1 Style: Seismic sway braces shall consist of galvanized steel aircraft cables or steel angles or struts. Cables braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads with a minimum safety factor of two (2). Brace end connections shall be steel assemblies that swivel to the final installation angle. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps. Do not mix cable and steel braces to brace the same system or equipment. Manufacturers: Mason #SCB Series or #SCBH Series, steel brace assemblies shall be Mason #SSB Series, #SSBS Series or #SHB Series, and rod clamps shall be Mason #SRC Series or #UCC Series or equal.

2.9 FLEXIBLE PIPING CONNECTORS

A. F-1 Style: Flexible spherical expansion joints for pump connections. Shall employ peroxide cured EPDM in the covers, liners and Kevlar tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16" to 24" may be single sphere. Sizes 3/4" to 1 1/2" may have threaded bolted flange assemblies, one sphere and cable retention. 14" and smaller connectors shall be rated at 250 psi up to 190F with a uniform drop in allowable pressure to 190 psi at 250F. 16" and larger connectors are rated 180 psi at 190F and 135 psi at 250F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5-minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Manufacturer shall provide pre-stretching charts for expansion joints when used in conjunction with isolated equipment. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2" thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Manufacturers: Mason #SAFEFLEX SFDEJ Series, #SAFEFLEX SFEJ Series, #SAFEFLEX SFDCR Series or #SAFEFLEX SFU Series and Control Rods Mason #CR, or equal.

B. F-2 Style: Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings.
   1. Sizes 1/2" (15 mm) to 2” (50 mm):
      a. EPDM or Kevlar core hose with stainless steel braid and brass end fittings. Swivel union ends for threaded nipples or copper sweat ends. Minimum 175 psig working pressure rating. Operating temperature range from 32°F to 225°F (0°C to 107°C). Hoses must have sufficient length, minimum 12” (300 mm) long, to accept 1/2” (12 mm) intermittent motion without failure. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

Manufacturers: IMI #Versaflow, Nexus #UF Series, Pro Hydronic Specialties, Titus, Victaulic, Hays Fluid Control, or equal.

2. Sizes 2-1/2" (65 mm) and larger:
   a. EPDM, Kevlar or corrugated stainless-steel core hose with stainless-steel braid. Threaded, flanged or brazed weld ends. Minimum 200 psig working pressure rating. Operating temperature range from 32°F to 225°F (0°C to 107°C). Manufacturers: Mason #FFL Flanged, #CPSB Copper, #CSAMN Threaded, or equal.

C. F-3 Style: Flexible 60° Vee or U-bend braided hose across building or expansion joints. Piping and equipment connections shall be protected against seismic damage by the insertion of braided flexible hose Vee assemblies rated for ±4" (100mm) seismic motion in all planes. Should the application include ±6" (150mm) thermal movement or thermal movement alone, install the Vee so the thermal movement is axial. Vees shall have a minimum burst pressure of four times their rated pressure. Vees in steel lines shall have stainless hose and braid. Copper lines, bronze hose and braid. Guiding and anchoring shall be as recommended by the manufacturer. Manufacturers: Mason #VFL flanged braided steel Series, #VMN Threaded Braided Stainless Steel Series or #VCPSB Copper Sweat Series, or equal.

2.10 FLEXIBLE DUCTWORK CONNECTORS

A. F-4 Style: Flexible ductwork connection fabricated of fiberglass canvas with fire resistant rated neoprene and UV resistant coating. Stainless steel metal edge banding.

B. Flexible Connections (Indoor Applications):
1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.
3. Shall be airtight, watertight and fire retardant.
4. Minimum density of 30 oz. per sq. yard.
5. Temperature range: -40°F to 200°F
6. Surface-Burning Characteristics: Maximum flame-spread index of 20 and maximum smoke-developed index of 40 when tested according to UL 723/ASTM E84.
7. Neoprene-only connectors are not allowed.
8. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal.
9. Manufacturers: Ventfabrics #Ventglas or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.

C. Flexible Connections (Outdoor Applications):
1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Hypalon (chlorosulfurated polyethylene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.
3. Shall be airtight, watertight and fire retardant. Resistant to sunlight, ozone and weather.
4. Minimum density of 26 oz. per sq. yard.
5. Temperature range: -50°F to 275°F
6. Surface-Burning Characteristics: Non-combustible as tested per UL 701. Or, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84.
7. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal.
8. Provide flexible cloth insulating blanket to encase flexible connections to maintain ductwork insulation integrity as follows:
   a. Jacket shall be UV and ozone resistant with Velcro attachment.
   b. Service Operating Temperature: 0-350°F.
   c. Jacket and Liner: silicon or teflon impregnated fiberglass or mineral wool cloth.

d. Insulation: Aerogel, 2” thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
e. Fastening: 2” Nomex Velcro or 1” straps and stainless steel D-rings.
f. Thread: Kevlar/stainless steel thread.
g. Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, or equal.

9. Manufacturers: Ventfabrics #Ventlon or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.

2.11 BRACING DEVICES FOR EQUIPMENT, PIPING, AND DUCTWORK

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company (VMC Group)
2. California Dynamics Corporation
3. Cooper B-Line, Inc.
4. Hilti, Inc.
5. Kinetics Noise Control
6. Loos & Co.
7. Mason Industries
8. Tolco Incorporated
9. Unistrut
10. ISAT, Inc
11. Vibro-Acoustics, Inc.
12. VMC Group

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least two (2) times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4” (6 mm) thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Hanger Rod Stiffener: Steel tube, steel slotted support system sleeve or reinforcing steel angle clamped to hanger rod are acceptable.

F. Bushings for Floor-Mounted Equipment Anchorage: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

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

I. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488. Minimum length of eight times diameter.

J. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 LOCATION AND APPLICATION OF VIBRATION ISOLATION EQUIPMENT

A. The following Tables provide schedules for minimum vibration devices required for isolation of mechanical equipment provided on the project. Refer to Part 2 above for device specifications. Coordinate with additional requirements recommended by device manufacturers. Sizes show below take precedent as the minimum requirements. Use the greater of the sizes shown as follows or shown on the drawings.

B. Unhoused Fans, Built-up Systems or Cabinet Fans Equipment Isolation:

TABLE 2: EQUIPMENT ISOLATION SCHEDULE – UNHOUSED FANS, BUILT-UP SYSTEMS, OR CABINET FANS

EQUIPMENT TYPE	EQUIPMENT LOCATION								
	ROOF AND FLOORS ON GREATER THAN 30' FLOOR SPAN (5))			UPPER STORY UP TO 30' FLOOR SPAN (5)			ON GRADE		
	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE
CENTRIFUGAL FANS									
CL I & II Up to 54-1/2" WD									
Up to 15 HP	S - 2/S - 1	1.5	B-1/B-3	S-2/S-1	0.75	B-1	S-2/S-1	0.75	B-1
20 – 50 HP	S-2	2.5	B-2	S-2/S-1	1.5	B-2	S-2/S-1	0.75	B-1
60 HP & Over	S-2	3.5	B-2	S–2	2.5	B-2	S-2/S-1	1.5	B-1
CL I &II 60"W.D & OVER/ALL CL III FANS									
Up to 15 HP	S-2	2.5	B-2	S-2/S-1	1.5	B-1	S-2/S-1	0.75	B-1
20 – 50 HP	S-2	2.5	B-2	S-2	2.5	B-1	S-2/S-1	1.5	B-1
60 HP & Over	S-2	3.5	B-2	S-2	2.5	B-1	S-2/S-1	1.5	B-1
AXIAL FLOWFANS									
Floor Mounted									
Up to 15 HP	S-1/S-2	1.5	B-1/B-3	S-1	0.75	B-1	S–1	0.75	NA
20 HP & Over	S - 2	3.5	B-2	S-1	1.5	B-2	S-1	0.75	NA
Suspended									
Up to 15 HP	H - 1	1.75	B-1/B-3	H-1	1.0	B-1	H–1	1.0	NA
20 HP & Over	H - 1	2.5	B-1/B-3	H-1	1.75	B-1	H-1	1.5	NA
UTILITY FAN SETS									
Floor Mounted	S - 2/S - 1	1.5	B-1/B-3	S-1	0.75	B-1	S-1	0.75	NA
Suspended	H-1	1.75	B-1/B-3	H-1	1.0	B-1	H-1	0.75	NA
CABINET FANS and FAN SECTIONS									
Floor Mounted									
Up to 15 HP	S-1(1)	1.5	NA	S-1	0.75	NA	S-1	0.75	NA
20 HP & Over	S-2(1)	2.5	B-2	S-1	1.5	NA	S-1	0.75	NA
Suspended									
Up to 15 HP	H-1	1.75	NA	H-1	1.0	NA	H-1	0.75	NA
20 HP & Over	H-1	2.5	NA	H-1	1.75	NA	H-1	1.75	NA

Notes:
(1) Alternate: Factory installed by equipment manufacturer.
(2) Provide full perimeter steel welded frame below equipment.
(3) Provide support per manufacturer's recommendation.
(4) For pipe and duct connections provide F-2 pipe and F-4 duct connectors.
(5) Span is the beam or girder distance between columns or exterior fixed wall supports.

D Miscellaneous Equipment Isolation

TABLE 5: EQUIPMENT ISOLATION SCHEDULE – MISCELLANEOUS EQUIPMENT

EQUIPMENT TYPE	EQUIPMENT LOCATION								
	ROOF AND FLOORS ON GREATER THAN 30' FLOOR SPAN (5)			UPPER FLOOR UP TO 30' FLOOR SPAN (5)			ON GRADE		
	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE	ISOLATOR TYPE	MINIMUM DEFLECTION (IN)	BASE TYPE
ROOFTOP AIR CONDITIONING UNITS									
Up to 20 Ton	S-2	1.5	C-1/C-3	S-2	1.5	C-1/C-3	NA	NA	NA
Over 20 Ton	S-2	2.5	C-2	S-2	2.5	C-2	NA	NA	NA

Notes:
(1) Alternate: Factory installed by equipment manufacturer.
(2) Provide full perimeter steel welded frame below equipment.
(3) Provide support per manufacturer's recommendation.
(4) For pipe and duct connections to units provide F-2 pipe and F-4 duct connectors.
(5) Span is the beam or girder distance between columns or exterior fixed wall supports.

3.2 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.3 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service or agency acceptable to authorities having jurisdiction. Indicate on Drawings, by details, schedules, or a combination of both, the locations where hanger rods for individual pipes and hanger rods for trapeze hangers require hanger rod stiffeners.

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

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

3.4 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

C. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

D. All vibration isolator systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

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

F. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

G. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner’s Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

H. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

I. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

J. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

K. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

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

M. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

N. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

O. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the Structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.5 VIBRATION ISOLATION OF PIPING

A. Horizontal Piping: The first three pipe supports from vibration isolated equipment must be vibration isolated to minimize fluid transmitted vibration. The static deflection of the pipe support isolators must be equal to the static deflection for the isolators supporting the connected equipment. Overhead piping shall suspend from Mason Type 30N spring hangers or equal. Floor supported piping shall rest on Mason Type SLR isolators or equal. Refer to contract drawings for additional vibration isolation requirements for piping. Where piping connects to mechanical equipment install Mason Type SFDEJ or SFU expansion joints or Mason Type FFL stainless hoses if Type SFDEJ or SFU is not suitable for the service.

B. Riser isolation: Risers that experience excessive thermal expansion shall be suspended from Mason Type 30N spring hangers or supported by Mason Type SLF(H) spring mountings, anchored with Mason Type ADA(H) anchors, and guided with Mason Type VSG(H) sliding guides. Horizontal pipe runs and branches shall be supported on Mason Type 30N spring hangers for the first three supports from the risers. Steel springs shall be selected to provide a minimum of 0.75"static deflection except in those expansion locations where additional deflection is required to limit load changes to + 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

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

3.7 ADJUSTING

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

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

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

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

3.8 AIR MOUNTING SYSTEM DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 230548

SECTION 230593

TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 WORK RELATED IN OTHER SECTIONS

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230900: Building Automation System (BAS) Controls.

C. Section 232113: Hydronic Piping, Valves and Specialties.

D. Section 233113: Air Distribution.

E. Division 26: Electrical.

1.2 SUMMARY

A. Scope: Extent of testing, adjusting and balancing work required by this Section is indicated on the drawings, in schedules, and by the requirements of this Section, and Section 230500 - Basic Mechanical Requirements.

B. Systems: Testing, adjusting and balancing specified in this Section shall include, but not be limited to, the following systems:
1. Air handling systems including supply, return and exhaust.
2. Air distribution ductwork including supply, return and exhaust.
3. Dedicated exhaust systems.
4. Building automation system controls.
5. Hydronic system including heating, chilled water and condenser water.
6. Steam distribution.
7. Smoke control system.
8. Underfloor air distribution system air leakage.
9. Instruction of Owner's personnel for future balancing of systems.

1.3 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Reference Standards
1. ANSI/ASHRAE Standard 111 - Measurement, Testing, Adjusting and Balancing of Building HVAC Systems (current edition).
2. ASHRAE - HVAC Applications Handbook: Chapter 38 - Testing, Adjusting and Balancing (current edition).
3. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings, Chapter 6 (current edition).
4. AABC - National Standards for Total System Balance.
5. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
6. SMACNA - HVAC Systems-Testing, Adjusting and Balancing.
7. SMACNA - HVAC Air Duct Leakage Test Manual.
8. ANSI - American National Standards Institute. Comply with the following:
   a. S1.4: Specifications for Sound Level Meters.
   b. S1.11: Specifications for Electroacoustics - Octave-Band and Fractional-Octave-Band Filters

9. Building Code, with State Amendments, Chapter 9 Fire Protection Systems.
10. Mechanical Code, with State Amendments, Chapter 4 Ventilation Air Supply.
11. Local Nonresidential Energy Code.

1.4 QUALITY ASSURANCE

A. Contractor's Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 5 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, is not the installer of the system to be tested and is otherwise independent of the project. Testing, adjusting, and balancing shall be performed by a certified NEBB technician or a certified AABC technician under direct field supervision of a Certified NEBB Supervisor or a Certified AABC Supervisor. Testing and balancing agency must submit qualifications for review and approval prior to acceptance for work.

B. Penalty: The Contractor shall submit the name of the organization he proposes to employ for approval within 30 days after contract award. If the Contractor fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

C. Retainages: In addition to any other sums retained or withheld pursuant to the provisions of this Contract, the amount of dollars will be withheld from payments to the contractor until such time as the work has been completed and accepted. In no event will this amount be paid to the Contractor prior to 60 days following acceptance of the project; during such time, the Contractor shall investigate and correct any reported deficiencies unless such deficiencies are a result of unauthorized tampering by building occupants.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 6 months.

E. Testing and balancing agency, as part of its contract, shall act as authorized inspection agency responsible to Consulting Engineer and Owner, and shall list all items that are installed incorrectly, require correction, or have not been installed in accordance with contract Drawings and Specifications, pertaining to air distribution, cooling and heating systems. The testing and balancing agency is required to provide written reports of all deficiencies and proposed recommendations to the Owner' Representative, Contractor, Architect and Engineer.

F. The testing and balancing agency shall provide with their bid a performance guarantee covering all phases of the work as herein specified.

G. The General and Mechanical Contractors shall cooperate with the selected testing and balancing agency in the following manner:
   1. Provide sufficient time before final completion dates so that tests and balancing can be accomplished.
   2. The various system installers, suppliers and contractors shall provide all required materials, labor and tools to make corrections when required without undue delay. Install balancing dampers and valves as required by testing and balancing agency.
   3. The contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of the same during each working day of testing and balancing.
   4. Testing and balancing agency shall be kept informed of any major changes made to the system during construction, and shall be provided with a complete set of Record Drawings.
   5. The General Contractor shall make space and other facilities available to the testing and balancing agency to enable their work to progress. The General Contractor shall schedule the work of other trades to avoid conflicts with this work.

H. All air balancing work shall be coordinated with other disciplines to comply with the meet or exceed the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, local amendments and State Energy Code.

1.5 SUBMITTALS

A. Conform to the Submittals requirements of Division 01.

B. Forms: The Contractor shall deliver a complete copy of either NEBB or AABC standard forms for testing and balancing work associated with the project. These forms shall serve as specific guidelines for producing final test report. Hybrid or non-standards forms are not acceptable.

C. Test Reports: Provide six (6) certified test reports, signed by the test and balance supervisor who performed the work. The final reports shall include key plans identifying all inlets and outlets. Final test reports shall be typed. Hand written reports are not acceptable.

D. Maintenance Data: Include, in maintenance manuals, copies of certified and approved test and balance reports and identification of instruments.

E. Qualifications: The Test and Balance Agency shall submit qualifications of all persons responsible for supervising and performing the on-site testing and balancing work and the name of the certifying agency, NEBB or AABC. Provide a reference list of five (5) similar size projects with contact person and telephone number.

F. LEED:
1. Air-Balance Report for Prerequisite EQp1: Documentation of work performed per ASHRAE 2.1, Section 7.2.2 - "Air Balancing”.
2. TAB Report for Prerequisite EAc2: Documentation of work performed per ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing”.

1.6 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.
1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.
2. The agenda shall include a general description of each air and water system with its associated equipment and operation cycles for heating and cooling.
3. The agenda shall include a list of all air and water flows to be performed at all mechanical equipment.
4. The agenda shall incorporate the proposed selection points for sound measurements, including typical spaces as well as sound sensitive areas such as conference rooms.
5. The agenda shall also include specific test procedures and parameters for determining specified quantities (e.g. flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements. Samples of forms showing application of procedures and calculations to typical systems shall be submitted.
6. Specific test procedures for measuring air quantities at terminals shall specify type of instrument to be used, method of instrument application (by sketch) and factors for:
    a. Air terminal configuration.
    b. Flow direction (supply or exhaust).
    c. Velocity corrections.
    d. Effective area applicable to each size and type of air terminal.
    e. Density corrections.
7. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date.

1.7 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met.
   1. Installation and start-up work on equipment or systems to be tested has been completed and documented.
   2. Work area scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.
   3. All architectural openings (doors, windows, and other openings) which may affect the operation of the system to be tested shall be in their completed normal positions and operation.
   4. All related mechanical systems which may affect the operation of the system to be tested shall be at their normal operating conditions.

PART 2 - PRODUCTS

2.1 TEST HOLES

A. Test holes and ports shall be provided in ducts, housings and pipes as directed by the Balancing Agency. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.

2.2 PATCHING MATERIALS

A. Material: Seal, patch and repair ductwork, piping and equipment drilled or cut for testing purposes.
   1. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.
   2. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

2.3 TEST INSTRUMENTS

A. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Owner's Representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.

B. Additional Instruments: Permanently installed measuring instruments, such as temperature and pressure gauges, shall be checked against Certified Calibrated instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

C. Cone Instruments: The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser/grille/register air flow measurements. The readout meters shall meet calibration requirements.

PART 3 - EXECUTION

3.1 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required by approved project drawings and specifications.

B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four-hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.
   1. All instruments shall be applied in accordance with the manufacturer's certified instructions.
   2. All labor, instruments, and appliances required shall be furnished by the Contractor. Permanently installed instruments used for the tests (e.g., flow meters and Btu meters) shall not be installed until the entire system has been cleaned and ready for operation.

3.2 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be provided and located as required by these specifications and drawings and as required by the building codes and the following:
   1. Obtain information from the Contractor who is to furnish the smoke detectors on the proper device placement and installation limitations and on the proper differential pressure across the sampling tubes of the duct detectors and for required air velocity range requirements.
   2. Installing Contractor shall review the manufacturer's installation guidelines for proper mounting locations.
   3. The testing and balancing agency shall be engaged to confirm that proposed mounting locations will not be adversely impacted by airflows.

B. Duct smoke detectors shall be tested in collaboration with the installing Contractor and project Fire Alarm Contractor to ensure proper air flow sampling and differential pressure.

3.3 DUCTWORK AIR LEAKAGE TESTING

A. Test and balance agency shall perform active air flow testing of ductwork systems or sections of ductworks. Agency shall inspect and confirm that all ductwork is sealed per the specification requirements prior to performing any testing. Calculate maximum allowable air leakage by system based on total design air flow rate and/or square footage of ductwork. Maximum allowable system air flow leakage shall not exceed 5% of total air volume, or the maximum allowable per local energy or mechanical codes where the allowable limit is less than 5%.

B. Representative sections totaling 10 percent, or greater, of the total installed duct area shall be tested. Where the tested 10 percent fails to comply with the requirements, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fails to comply then 100 percent of the total installed duct area shall be tested and verified to have a leakage rate that does not exceed the maximum allowable limit. Duct sections shall be selected by the Owner’s Representative. Obtain total duct surface area and air flow volumes for each duct section from the installing contractor. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

C. Additional ductwork leakage testing may be required to meet local energy and mechanical code requirements. Refer to local codes for applicability and requirements.

D. Ductwork systems to be leakage tested and procedures shall include:
   1. Testing shall be performed at 1.5 times the peak design outlet static pressure (external static pressure) from the air handling unit/fan, but not greater than the maximum SMACNA pressure rating of the ductwork construction classification.
   2. Testing is not required of flexible ductwork or ductwork downstream of VAV terminal units.
   3. Leakage through manufactured products, such as dampers, fire smoke dampers and terminal units may be excluded from the leakage calculations based on manufacturer stated values, at pressure, or these units may be temporarily sealed with painter’s tape or plastic sheeting during testing to seal any openings and must be removed after testing.
   4. Supply air ductwork from the outlet of the air handling unit/fan to inlet side of terminal units or connection to flexible ductwork. Duct leakage testing is not required downstream of terminal units.
   5. All supply, return and exhaust air ductwork located outside the building envelope.

6. Return and exhaust air ductwork located in unconditioned spaces from inlet of the air handling unit/fan to the ductwork terminations upstream of each return air grille.
7. Laboratory and fume hood exhaust air ductwork from inlet of the air handling unit/fan to the connection at the remote exhaust air grille or fume hood connection.
8. Kitchen exhaust air ductwork from inlet of the exhaust fan to the connection at the remote exhaust hood.

E. For buildings under the jurisdiction of the UMC or CMC provide duct leakage testing in compliance with maximum allowable leakage quantities per code Section 603.10.1, but in no case greater than 5% of the total system air flow volume. Ductwork shall be leak-tested in accordance with the procedures described in SMACNA HVAC Air Duct Leakage Test Manual. The permitted duct leakage shall be not more than the following:
1. $L_{MAX} = C_L P^{0.65}$ where:
   a. L_{MAX}=maximum permitted leakage (ft^3/min/100 sf [0.0001 (m^3/s)/m^2] duct surface area.
   b. $C_{L=}$ Six (6), SMACNA duct leakage class (ft^3/min/100 sf [0.0001 (m^3/s)/m^2] duct surface area at 1 inch water column (0.2 kPa).
   c. P=test pressure, which shall be equal to the design duct pressure class rating in inches of water column (kPa).

F. Additional leakage testing in California, per the energy code, requires that duct systems shall be sealed to a leakage rate not to exceed 6% of the fan flow if the duct systems are:
1. Connect to a constant volume, single zone system, air conditioners, heat pumps or furnaces, and,
2. Serve less than 5,000 square feet of floor area, and
3. Have more than 25% duct surface area located in one or more of the following places:
   a. Outdoors, or,
   b. In a space directly under a floor where the U-factor of the roof is greater than the U-factor of the ceiling, or,
   c. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or,
   d. In an unconditioned crawlspace, or,
   e. In other unconditioned spaces.

G. Ductwork installer shall prepare ductwork for pressure testing as deemed appropriate to maintain construction schedule. Ductwork may be tested as total systems or in sections. Sectional testing will require documentation to prove the totalized system leakage is within allowable range of entire system. Ductwork inlets and outlets may be temporarily sealed airtight with plastic, or other means, to facilitate testing pressures.

H. Testing may occur through ductwork devices such as balancing dampers, smoke fire dampers and coils. Manufacturer provided air leakage allowances for such devices may be excluded from duct leakage measurement but must be documented in final report.

I. The leakage rate shall be confirmed through field verification and diagnostic testing in accordance with procedures defined by Oriflow Air Leakage Test, or equivalent procedure. Perform all testing utilizing a duct leakage testing system, Oriflow Duct Leakage Tester or equal, with calibrated fan, orifice, gauges, ductwork, pressure tips and tubing.

3.4 UNDERFLOOR PLENUM AIR LEAKAGE TESTING

A. Test and balance agency shall perform active air leakage testing of raised floor plenums. Agency shall inspect and confirm that all plenums are sealed per the specification requirements prior to testing. Agency shall coordinate with commissioning agent and all installing contractors and identify areas where floor plenum integrity has been compromised. Reports of inspections will be submitted to the general contractor.

B. Plenum Mock-Up & Testing: All subcontractors responsible for constructing or penetrating the underfloor plenum must participate in the construction of an on-site plenum mockup consisting of all planned plenum components, penetrations, seams and openings. The mock-up plenum is to be inspected and tested by the test and balance agency and an independent commissioning agent for air leakage to verify that it was constructed and sealed in accordance with specifications and drawings including meeting the air leakage requirements.

C. Air leakage requirement for mock-up and final plenums: total air leakage from each plenum should be no more than 5% of the design airflow when tested at a static pressure of 0.10” w.g. (25 Pascals). Areas with leakage exceeding 5% shall be inspected, repaired and retested until such time that plenum leakage is less than 5% of the design air flow for each floor area.

D. Perform all pressure testing using a calibrated blower door apparatus, such as a Minneapolis Blower Door model 3 as manufactured by the Energy Conservatory. The fan discharge plenum shall be sized to match a typical floor tile, such as 24” x 24”. A minimum of three measurements shall be obtained to assure the average pressure does not exceed the allowable leakage rate. Document results in TAB report.

3.5 AIR SYSTEM PROCEDURES

A. Adjustments: Adjust all air handling systems to provide design air quantity to or through, each component, and to maintain stable and comfortable interior temperatures, free of drafts or stagnant air conditions.

B. Equalizers: Equalizing devices shall be adjusted to provide uniform velocity across the inlets (duct side for supply) of terminals prior to measuring flow rates.

C. Balance: Flow adjusting (volume control) devices shall be used to balance air quantities (i.e., proportion flow between various terminals comprising system) to the extent that their adjustments do not create objectionable air motion or sound (i.e., in excess of specified limits).
   1. Balancing between runs (submains, branch mains, and branches) generally shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.
   2. Restriction imposed by flow regulating devices in or at terminals shall be minimal.
   3. Final measurements of air quality shall be made after the air terminal has been adjusted to provide the optimum air pattern of diffusion and as indicated on the air distribution drawings.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds or axial-flow fan wheel blade pitch. Damper restriction of a system's total flow may be used only for systems with direct-connected fans (without adjustable pitch blades), provided system pressure is less than 0.5” w.g. and sound level criteria are met.

E. Air Measurement: Where air quantity measuring devices are specified in other sections such systems shall be used as a cross-check of portable measuring equipment.
   1. Except as specifically indicated herein, pitot tube traverses shall be made of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE "Handbook Fundamentals Inch Pound Edition."
   2. For ducts serving modular office areas with movable partitions, which are subject to change, pitot tube traverses may be omitted provided the duct serves only a single room or space and its design volume is less than 2000 cfm. In lieu of pitot tube traverses, airflow in the duct shall be determined by totaling volume of individual terminals served, measured as described herein.
   3. Where duct's design velocity and air quantity are both less than 1000 (fpm/cfm), air quantity may be determined by measurements at terminals served.

F. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.

G. Air Terminal Balancing: Generally, measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda. Laboratory tests shall be conducted to prove accuracy of testing methodology and test data when so directed. Such tests shall be conducted in conformance with applicable ASHRAE or American Society of Mechanical Engineers (ASME) codes and shall be performed at no additional cost to Owner.

H. Air Motion: Air motion and distribution shall be as specified and indicated on drawings. The Contractor, at no additional cost to the Owner shall, in addition to air motion and direct measurements, perform smoke tests as requested to demonstrate the air distribution and pattern from air terminals and outlets.

I. Air system test and balance procedures shall include, but not be limited to the following requirements:
   1. Test and adjust blower RPM to design requirements.
   2. Test and record motor full load amperes.
   3. Make pitot tube traverse of main supply ducts and obtain design CFM at fans.
   4. Test and record system static pressures, suction pressure directly at system fan inlet, and outlet pressure directly at system fan outlet or discharge. Test and record static pressure across each component of air handling system (coils, filters, etc.).
   5. Test and adjust system for design CFM recirculated air.
   6. Test and adjust system for design CFM outside air.
   7. Test and record entering air temperatures.
   8. Test and record leaving air temperatures.
   9. Adjust all supply, return and exhaust air ducts to proper design CFM.
   10. Adjust all zones to proper design CFM, supply and return.
   11. Test and adjust duct systems and each diffuser, grille, and/or register to within 10% of design requirements.
   12. Each grille, diffuser and register shall be identified as to location and area.
   13. Operate each variable frequency drive (VFD) and verify controls installation is complete.
   14. Size, type and manufacturer of VAV boxes, diffusers, grilles, registers and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.
   15. Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustment.
   16. In cooperation with the control manufacturer's representative, setting adjustments of automatically operated dampers to operate as specified, indicated, and/or noted. Testing agency shall check all controls requiring adjustment by control installers. Room thermostats shall be checked for cooling and heating response.
   17. All diffusers, grilles and registers shall be adjusted to minimize drafts in all areas.
   18. Adjust overall system balances to allow all self-closing exterior doors to close from any open position. Maximum interior air pressure in all operational modes shall not exceed 0.05" static pressure relative to the outside air pressure. Comply with chapter 10 of the Building Code to assure that self-closing doors will release with a maximum force of 15 pounds.
   19. As part of the work of this contract, the HVAC contractor shall make any changes in the pulleys, belts and dampers or the addition of dampers required for correct balance as recommended by air balance agency, at no additional cost to Owner.
   20. After air balancing is completed and RPM determined, HVAC Contractor shall provide fixed pitch pulleys.
   21. All mixing boxes, VAV air valves, control dampers, smoke dampers and similar devices which operate at 100% shut off shall be tested for leakage.
   22. Variable Air Volume Fan Systems: The primary balancing mode is 100% outside air with all terminal boxes on a full call for cooling. Also check and record performance at minimum outside air with all terminal boxes on call for full cooling and at minimum outside air with all terminal boxes on call for full heating and at minimum outside air in the deadband range with

no call for heating or cooling. Verify that the systems are operating on a stable part of the fan curves in each mode. Record final duct static controller settings.

23. Provide testing of underfloor air distribution plenum floor mock-ups and final floor installation to document that plenum does not exceed 5% air leakage rate at maximum 0.10" w.g. positive differential pressure.

3.6 ADA COMPLIANCE

A. All air balancing work shall be coordinated with other disciplines to comply with meeting or exceeding the minimum requirements of the Americans with Disabilities Act (ADA), Chapters 9 and 10 of the Building Code, local amendments and State Energy Code. Final air balancing for all systems in each space shall be verified and adjusted as necessary to meet the following requirements during peak ventilation, smoke control mode, partial ventilation and minimum ventilation modes during occupied and non-occupied hours. The following requirements are provided as consolidated list of minimum ADA requirements:

1. The required force for pushing or pulling open a door other than fire doors shall not exceed 5 pounds.
2. At fire doors the required opening force shall not exceed 15 pounds.
3. At fire doors the doors shall be set in motion when subjected to a force not exceeding 30 pounds.
4. At fire doors the doors shall swing to a full open position when subjected to a force not exceeding 15 pounds.
5. The force to operate door latch releases shall not exceed 5 pounds.
6. The differential pressure between the building lobby and outside shall remain positive between 0.01" w.g., minimum, and 0.05" w.g., maximum, during operational hours.

3.7 SMOKE CONTROL TESTING

A. Coordination

1. Smoke control testing, adjusting and balancing is required in high rise building as defined by the Building Code and scope defined in the Rational Analysis per Chapter 9 of the Building Code and as required by local ordinances.
2. Review Rational Analysis and inform Owner's Representative of any issues that need to be resolved prior to testing, adjusting and balancing.
3. Verify that building automation control system and fire alarm systems are complete and operational as required to position equipment and dampers as required during a smoke event.
4. Verify that all ductwork is sealed and that leakage testing is complete and final leakage report states that maximum allowable leakage does not exceed 5% in all smoke control ductwork (exhaust, supply, outside air intake).

B. Passive Barriers

1. Verify that construction of all smoke barriers is complete with necessary sealants, door seals and paint.
2. Verify that all passive barrier testing has been completed. Review passive barrier leakage test report to confirm that all barrier leakage is within acceptable ranges as allow per Chapter 9 of the Building Code.

C. Active Pressurization During Smoke Control Mode

1. Test and verify that the minimum pressure difference across each smoke barrier (corridors, stairwells, lobbies, elevator equipment rooms, etc.) shall be maintained at 0.05" w.g. (12.5 Pa) or greater with system fans operating in a smoke control mode.
2. Verify that each stairwell barometric relief damper opens at 0.05" w.g. (12.5 Pa), maximum, to relive a minimum of 2,500 cfm.
3. Verify that minimum pressure differential of 0.05" w.g. (12.5 Pa) is maintained from vestibule to the stairwell and from the vestibule to the floor area.
4. Verify that all doors operate per ADA requirements as referenced in previous section.

5. Coordinate with BAS contractor to set the variable frequency drive speeds as required for normal and smoke control modes.

3.8 AIR SYSTEM DATA

A. Report: The certified report shall include for each air handling system the data listed below.
   1. Equipment (Fan or Factory Fabricated Station Unit):
      a. Installation data
         1) Manufacturer and model
         2) Size
         3) Arrangement, discharge and class
         4) Motor hp, voltage, phase, cycles, and full load amps
         5) Location and local identification data
      b. Design data
         1) Data listed in schedules on drawings and specifications.
      c. Fan recorded (test) data
         1) CFM
         2) Static pressure (suction and discharge, across each coil and filter set)
         3) RPM
         4) Motor operating amps
         5) Motor operating bhp
   2. Duct Systems:
      a. Duct air quantities (maximum and minimum) - main, submains, branches, outdoor (outside) air, total air, and exhaust:
         1) Duct size(s)
         2) Number of pitot tube (pressure measurements)
         3) Sum of velocity measurements (Note: Do not add pressure measurements)
         4) Average velocity
         5) Recorded (test) cfm
         6) Design cfm
      b. Individual air terminals
         1) Terminal identification supply or exhaust, location and number designation
         2) Type size, manufacturer and catalog identification applicable factor for application, velocity, area, etc., and designated area
         3) Design and recorded velocities - fpm (state "core," "inlet," etc., as applicable)
         4) Design and recorded quantities - cfm (deflector vane or diffusion cone settings)

3.9 WATER SYSTEM PROCEDURES

A. Preparation:
   1. Open all valves to full open position. Close coil bypass stop valves. Set mixing valve to full coil flow.
   2. Remove all strainers and clean same. Reinstall.
   3. Examine water system and determine if water has been treated and cleaned.
   4. Check pump rotation.
   5. Check expansion tank to determine they are not air bound and the system is completely full of water.
   6. Check all air vents at high points of water systems and determine that all are installed and operating freely.
   7. Check operation of automatic bypass valve.
   8. Operate each variable frequency drive (VFD) and verify controls installation is complete.
   9. Check and set operating temperatures of all equipment at design requirements.
   10. Complete air balance must have been accomplished before actual water balance begins.

B. Adjustment: All heating, cooling and condensing water systems shall be adjusted to provide required quantity to or through each component.

C. Metering: Water quantities and pressures shall be measured with calibrated meters.
   1. Venturi tubes, orifices, or other metering fittings and pressure gauges shall be used to measure water flow rates and balance systems. Systems shall be adjusted to provide the approved pressure drops through the heat transfer equipment (coils except room units, converters, etc.) prior to the capacity testing.
   2. Where flow metering fittings are not installed, in air/water type heat transfer equipment, flow balance shall be determined by measuring the air side energy differential across the heat transfer equipment. Measurement of water temperature differential shall be performed with the air system, adjusted as described herein, in operation.

D. Automatic Controls: Automatic control valves shall be positioned for full flow through the heat transfer equipment of the system during tests.

E. Flow: Flow through bypass circuits at three-way valves shall be adjusted to equal that through the supply circuit, when the valve is in the bypass position.

F. Distribution: Adjustment of distribution shall be effected by means of balancing devices (cocks, valves, and fittings) and automatic flow control valves as provided. Manual service valves shall not be used for balancing.
   1. Where automatic flow control valves are utilized in lieu of Venturi tubes, only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.

G. Special Procedures: Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.

H. Water System Test and Balance Procedure: Perform the following tests, and balance each system in accordance with the following requirements:
   1. Set chilled, heating and condenser water pumps to proper gallons per minute delivery.
   2. Adjust chilled water flow though chiller(s).
   3. Adjust heating water flow through boiler(s).
   4. Adjust condenser water flow through cooling tower(s).
   5. Test and record entering and leaving water temperatures through chillers, boilers, heat exchangers and cooling towers/fluid coolers.
   6. Test and record water temperatures at inlet and outlet side of each terminal unit. Note rise or drop of temperatures from source.
   7. Proceed to balance each terminal unit.
   8. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
   9. After adjustments to coils are made, recheck settings at the pumps, chiller, boilers, and cooling towers and readjust if required.
   10. Record and check the following items at each coil.
      a. Inlet water temperatures.
      b. Leaving water temperatures.
      c. Water pressure drop of each coil.
   11. Pump operating suction and discharge pressures and final total dynamic head.
   12. List all mechanical specifications of pumps.
   13. Rated and actual running amperage of pump motor.
   14. Water metering device readings.

3.10 WATER SYSTEM DATA

A. Report: The certified report for reach water system shall include the data listed below.
   1. Pumps:
      a. Installation data
         1) Manufacturer and model
         2) Size
         3) Type drive
         4) Motor hp, voltage, phase, and full load amps
      b. Design data
         1) GPM
         2) Head
         3) RPM and amps
      c. Recorded data
         1) Discharge pressures (full-flow and no-flow)
         2) Suction pressures (full-flow and no-flow) operating head
         3) Operating gpm (from pump curves if metering is not provided) no-load
         4) Amps
         5) Full-flow amps
         6) No-flow amps
   2. Air Heating and Cooling Equipment:
      a. Design data
         1) Load in Btuh or MBh
         2) GPM
         3) Entering and leaving water temperature
         4) Entering and leaving air conditions (DB and WB)
         5) CFM
         6) Water pressure drop
         7) Entering steam pressure
      b. Recorded data
         1) Type of equipment and identification (location or number designation)
         2) Entering and leaving air conditions (DB and WB)
         3) Entering and leaving water temperatures
         4) GPM
         5) Temperature rise or drop
         6) Entering steam pressure
   3. Water Chilling Units:
      a. Installation data
         1) Manufacturer and model
         2) Motor hp, voltage, cycles, phase, and full load amps
         3) Part load amperes
         4) GPM - chiller and condenser
         5) Water pressure drop - chiller and condenser
         6) Entering and leaving water temperature - chiller and condenser
      b. Recorded data (chiller and condenser)
         1) GPM
         2) Water pressure drop
         3) Entering and leaving water temperature
         4) Amperes
   4. Cooling Towers and Fluid Coolers:
      a. Installation data
         1) Manufacturer and model
         2) Motor hp, voltage, cycles, phase, and full load amps
         3) Part load amperes
         4) GPM

5) Water pressure drop
6) Entering and leaving water temperature

b. Recorded data
1) GPM
2) Water pressure drop
3) Entering and leaving water temperature
4) Amperes

5. Boilers:
a. Installation data
1) Manufacturer and model
2) Motor hp, voltage, cycles, phase, and full load amps
3) Part load amperes
4) GPM
5) Water pressure drop
6) Entering and leaving water temperature

b. Recorded data
1) GPM
2) Water pressure drop
3) Entering and leaving water temperature
4) Amperes

6. Heat Exchangers:
a. Installation Data
1) Manufacturer, model, and type
2) Flow rate
3) Inlet (entering) and outlet (leaving) temperatures
4) Inlet (entering) and outlet (leaving) pressures

b. Recorded Data
1) Flow rate
2) Entering and leaving water temperatures
3) Entering and leaving pressures

3.11 HEAT EXCHANGER CAPACITY VERIFICATION

A. Air coil capacities shall be verified from air side measurement data. Capacities of coils shall be the difference of the energy carried by the air between the upstream and downstream of the coils.

B. The measured air flow rate for the fan may be used for air coil capacity calculations providing no ducted bypassing of coil is occurring.

C. Water/water heat exchanger equipment capacity shall be verified by measuring the flow rate and temperature differential of the water.

D. Capacity verification shall be performed after air and water systems have been balanced.

E. False load shall be applied if the upstream air or water does not meet the specified conditions at the time of test.

3.12 SOUND TEST PROCEDURES

A. Scope: Tests of sound levels shall be made at each selection point as described in the following:
1. Each normally occupied room or space, including, but not limited to, the following:
a. Offices, open and enclosed.
b. Conference rooms and breakout rooms.
c. Lobbies and waiting rooms.
d. Break rooms.
e. Retail spaces.

f. Dining area.
g. Hospitality spaces, guest rooms and patient rooms.
h. IT and data equipment rooms.

2. Within five feet of each piece of noise generating equipment, such as chillers, cooling towers/fluid coolers, fans, compressors, pumps, and condensers. Or, within the documented sound measurement distance as listed in the equipment manufacturer literature.
3. Within five feet of property lines where mechanical equipment is located outside the building.

B. Timing: Sound level measurements shall be taken at times when the building is unoccupied, or when activity in surrounding areas and background noise level in areas tested are at a minimum and relatively free from sudden changes in noise levels.
1. Measurements shall be taken with all equipment turned off, except that being tested.
2. The required sound levels shall be measured at any point within a room not less than 6 feet from any equipment or air terminal and not closer than 3 feet from any floor, wall, or ceiling surface.

C. Meters: Sound levels shall be measured with a sound meter complying with ANSI S1.4. The "A" scale shall be used to measure over all sound levels. To determine the specified octave band levels, the above sound level meter, set on "C" scale, shall be supplemented by an octave band analyzer complying with ANSI S1.11.

D. Equipment Components: The "Equipment Component" of room sound equals LPt-C. The "Equipment Component" of room sound (noise) levels shall be determined for each of eight octave bands as follows:
1. Measure room sound pressure level "LPb" with equipment to be tested shut off.
2. Measure room sound pressure level "LPt" with equipment to be tested turned on.
3. Calculate LPt-LPb; if this value is less than 1, applicable test must be rerun with lower background level (LPb) unless LPt is within sound pressure level specified for equipment.
4. Determine "c" from the table below.

LPt-LPb (db)	c (db)
1	7
2	4
3	3
4 to 4- ½	2
5 to 5- ½	1 – ½
6 to 7- ½	1
8 to 12	½
over 12	0

3.13 SOUND LEVEL DATA

A. Report: Certified report shall record data on sound levels, taken at each selected location, as follows:
1. Source of sound and location.
2. Diagram or description of relationship of sound source to measuring instrument.
3. "A" scale readings equipment being tested turned off (ambient) equipment being tested turned on (operating conditions).
4. Readings at each specified octave band frequency for equipment being tested turned off (ambient level) and equipment being tested turned on (operating conditions).
5. "Equipment Components" of sound (noise) levels with applicable calculations per "Sound Test Procedures".
6. Graph showing relationship between pressure levels specified and recorded readings

B. Retest: Subsequent to any correctional construction work, such as acoustic corrections, measurement shall be made to verify that associated air and water quantities, as previously measured, have not been disrupted.
   1. Certified report shall record all sound data, and their locations, after final adjustments of air and water systems involves

3.14 MEASUREMENT TOLERANCES

A. Set system air flow rates and water flow rates within the following tolerances:
   1. Supply, return, and exhaust fans and equipment with fans: +/- 10%.
   2. Air outlets and inlets: +/- 10%.
   3. Heating water flow rate: +/- 10%.
   4. Chilled water flow rate: +/- 10%.
   5. Condenser water flow rate: +/- 10%.

3.15 CERTIFIED REPORTS

A. Submittals: Six (6) copies of the reports described herein, covering air and water system performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final tests and inspection.

B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be included.

C. Reports: Reports shall conspicuously identify items not conforming to contract requirements, or obvious malfunction and design deficiencies.

D. Certification: Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

3.16 FINAL COMMISSIONING TESTS, INSPECTIONS AND ACCEPTANCE

A. Scope: Test shall be made to demonstrate that capacities and performance of air and water systems comply with contract requirements.
   1. At the time of final inspection, the Contractor shall recheck, random selection of data (water and air quantities, air motion, and sound levels) recorded in the certified report. In addition, all courtrooms, auditoriums, and conference rooms shall be rechecked.
   2. Points and areas for recheck shall be selected by the commissioning team.
   3. Measurement and test procedures shall be the same as approved for work forming basis of certified report.
   4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from design, or a sound level greater than 2 db or more than recorded in the certified report listings, as 10 percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost. Retainage time shall be based on the date of the final acceptance of the certified report.

C. Marking of Settings: Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that

adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

END OF SECTION 230593

SECTION 230716

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:
   1. HVAC Equipment Insulation section includes the following equipment that is not factory insulated
      a. Heat exchangers.
      b. Converters.
      c. Chilled-water pumps.
      d. Condenser-water pumps.
      e. Heating hot-water pumps.
      f. Heat-recovery pumps.
      g. Steam condensate pumps.
      h. Expansion/compression tanks.
      i. Air separators.
      j. Thermal storage tanks.
      k. Deaerators.
      l. Steam condensate tanks.
      m. Steam flash tanks, flash separators, moisture separators, and blow-off tanks.
      n. Piping system filtration unit housings.
      o. Outdoor, aboveground, heated, fuel-oil storage tanks.
      p. Generator exhaust systems.

B. Types of mechanical insulation specified in this Section include the following:
   1. Glass fiber and mineral wool.
   2. Closed cell phenolic.
   3. Polyisocyanurate.
   4. Calcium silicate.
   5. Cellular glass.
   6. Flexible elastomeric closed-cell foam.
   7. Aerocel.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Division 22: Plumbing.

B. Section 230500: Basic HVAC Materials and Methods.

C. Section 232113: Hydronic Piping, Valves and Specialties.

1.3 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 33^{o} F, as stated in ASHRAE fundamentals under 99% column for winter design conditions.

I. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.4 INSULATION INDUSTRY DEFINITIONS

A. UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.

B. EPA: Environmental Protection Agency.

C. WHO: World Health Organization.

D. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film layer leaving no paper exposed.

E. ASJ: All Service Jacket (no outer film).

F. SSL+: Self-Sealing Lap with Advanced Closure System.

G. SSL: Self-Sealing Lap.

H. FSK: Foil Scrim Kraft; jacketing.

I. FSP: Foil Scrim Polyethylene jacketing

J. PSK: Poly Scrim Kraft; jacketing.

K. PVC: Polyvinyl Chloride.

L. FHC: Fire Hazard Classification

M. Glass Mineral Wool: Interchangeable with fiber glass, but replacing the term in the attempt to disassociate and differentiate Glass Mineral Wool from the potential health and safety risk of special purpose or reinforcement products that do not meet the bio solubility criteria of insulation made from glass. Rock Mineral Wool will replace the traditional Mineral Wool label. Both are used in lieu of the Mineral Fiber label.

N. ECOSE Technology: a proprietary binder system based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. ECOSE Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

O. UL GREENGUARD Gold Certification: (formerly known as GREENGUARD Children & Schools Certification) offers stricter certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in

environments such as schools and healthcare facilities. It is referenced by both The Collaborative for High Performance Schools (CHPS) and the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

P. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

Q. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

R. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

S. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

T. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to confirm they are free of Red List chemicals and materials. The Red List represents the “worst in class” materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

U. Underwriter’s Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

V. UL Environment Claims Validation (ECV): service and label tests a manufacturer’s product and validates that the environmental claims they make in their marketing and packaging materials are factual. This ECV service enables products to qualify for LEED® MR Credit 4 Recycled Content LEED-NC 2009 or New LEED V-4 Building product disclosure and optimization – sourcing of raw materials.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
   1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
      a. B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plat.
      b. C165 - Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
      c. C168 – Terminology for Thermal Insulation
      d. C177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission.
      e. Properties by Means of the Guarded-Hot-Plate Apparatus.
      f. C195 - Specification for Mineral Fiber Thermal Insulating Cement.
      g. C196 - Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
      h. C302 - Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
      i. C303 - Test Method for Density of Preformed Block-Type Thermal Insulation.
      j. C305 - Test for Thermal Conductivity of Pipe Insulation.
      k. C356 - Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
      l. C411 - Test for Hot-Surface Performance of High Temperature Thermal Insulation.
      m. C423 – Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
      n. C449 - Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.

o. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
p. C533 - Specification for Calcium Silicate Block and Pipe Thermal Insulation.
q. C534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
r. C547 - Specification for Mineral Fiber Preformed Pipe Insulation.
s. C552 - Specification for Cellular Glass Block and Pipe Thermal Insulation.
t. C553 - Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).
u. C592 - Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
v. C612 - Specification for Mineral Fiber Block and Board Thermal Insulation.
w. C795 – Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.
x. C921 - Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
y. C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
z. C1071 - Standard Specification for Thermal and Acoustical Insulation.
aa. C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
bb. C1617 Standard Specification for Thermal Insulation for use in Contact with Austenitic Stainless Steel.
cc. D1667 – Standard Specification for Flexible Cellular Material-Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
dd. E84 - Test Method for Surface Burning Characteristics of Building Materials.
ee. E119 - Test for Fire Resistance.
ff. G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
gg. G22 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90 - Energy Conservation in New Building Design.
3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 255 - Test Methods, Surface Burning Characteristics of Building Materials.

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

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Corrosiveness: Provide insulation such that when tested in accordance with the following test, the steel plate in contact with the insulation shows no greater corrosion than sterile cotton in contact with a steel plate for comparison.
   1. Test Specimen: Two specimens shall be used, each measuring 1” by 4” by approximately 1/2” thick.
   2. Apparatus: Provide a humidity test chamber in which two polished-steel test plates, 1” wide, 4” long and 0.020” thick, shall be placed. Plates shall be clear finish, cold-rolled strip steel, American quality, quarter hard, temper No. 3, weighing 0.85 lbs./sq. ft.
   3. Procedure: The steel test plates shall be rinsed with cp benzol until their surfaces are free from oil and grease and allowed to dry. One piece of cold-rolled steel shall be placed between the two insulation specimens and secured with tape or twine. The test specimen and uncovered plate shall be suspended vertically in an atmosphere having a relative humidity of 95% (plus or minus 3%), and a temperature of 120°F (plus or minus 3°F), for 96 hours, and then be examined for corrosion.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

G. Sustainable Project Requirements:
   1. Formaldehyde Free: Third party certified with UL Environment Validation or Scientific Certification Systems (SCS).
   2. Biosoluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products (EUCEB).
   3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation Products, provide materials complying with the testing and products requirements of UL GREENGUARD standards for Low-Emitting Products.
   4. Living Building Challenge-Declare Red List Free.

1.6 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9)
   2. Octabrominated diphenyl ether (CAS#32536-52-0)
   3. Decabrominated diphenyl ether (CAS#1163-19-50

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.7 LEED ACTION SUBMITTALS: (NOTE TO EDITOR - IF YOUR PROJECT HAS LEED REQUIREMENTS RELATED TO INSULATION MATERIALS, YOU NEED TO EDIT THE FOLLOWING LIST OF DOCUMENTATION REQUIREMENTS.)

A. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

B. Product Data for Credit MR 5 Regional Materials: For products and materials to comply with requirements for regional materials, provide documentation indicating location of product or material, manufacturing location and the point of extraction, harvest or recovery for each raw material. Include

distance to Project, contractor cost for each regional material, and percent by weight that is considered regional.

C. LEED v 4, Product Data for Credit EA 2: For products and materials significant to the energy performance of a structure, provide documentation that indicates that insulation levels are significant to increasing the level of energy performance beyond the prerequisite standard.

D. LEED v 4, Product Data for Credit MR 2: For products and materials to comply with Building Product Disclosure & Optimization, provide data/evidence that substantiates Environmental Product Declaration and Multi Attribute Optimization requirements.

E. LEED v 4: Product Data for Credit MR 3: For products and materials to comply with requirements for regional materials, provide documentation indicating location of product or material, manufacturing location and the point of extraction, harvest or recovery for each raw material. Include distance to Project, contractor cost for each regional material, and percent by weight that is considered regional.

F. LEED v 4, Product Data for Credit MR 4: For products having recycled content documentation; indicating percentages by weight of post-consumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.

G. LEED v 4, Product Data for Credit EQ 2: For products and materials to comply with low emittance standards, provide documentation substantiating that insulation products comply with requisite low emittance standards.

H. LEED v 4, Product Data for Credit EQ 5: For products and materials to meet the standard for both thermal comfort design and thermal comfort control, provide data to support that insulation products are significant to thermal comfort design and thermal comfort control.

I. LEED v 4, Product Data for Credit EQ 9: For products and materials that contribute to the design and performance of workspaces that promote occupants well-being, productivity, and communication, provide data/documentation supporting acoustical benefits of Glass Mineral Wool insulation products.

J. Laboratory Test Reports for Credit IEQ 4: For adhesives and 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."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.9 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Comply with requirements in "PART 3-EXECUTION, Table 1: Equipment Insulation Type Required" for application of insulating materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall be certified UL GREENGUARD Gold or Indoor Advantage Gold if possible.

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

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

F. Each insulation material has been provided a descriptive key code, such as EI-A, to simplify the organization and application of materials in following sub-sections.

G. Acceptable manufacturers include Knauf, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix, Aeroflex, Armacell, Pacor or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.2 EQUIPMENT INSULATION (IDENTIFIED BY KEY CODE EI AND IN TABLE 1)

A. **EI-A**, Rigid Hydrous Calcium Silicate:
1. Applications: High temperature insulation for piping and equipment and for placement at piping hangers and supports.
2. Compliant with ASTM C165, C302, C356, C447, C533, C665, C1338 and E84.
3. Maximum Service Temperature: 1200°F (650°C).
4. Thermal conductivity (K-value): 0.389 Btu•in./(hr•ft²•ºF), or less, at 200°F (93°C). Thickness as required to meet energy code requirements.
5. Nominal density is 14 lbs./cu. ft. or greater.
6. Compressive Strength (block): Minimum of 100 psi to produce 5% compression as tested per ASTM C165.
7. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =0 ratings as tested per ASTM E84.
8. Tie Wire: 16-gauge stainless steel with twisted ends on maximum 12” centers.
9. Product must contain corrosion inhibiting chemistry.
10. Manufacturers: Johns Manville Industrial Insulation Group #Thermo-12 Gold or equal.

B. **EI-B,** Rigid Closed-Cell Cellular Glass:
1. Applications: Rigid closed cell glass impermeable to water and water vapor for insulating buried piping and equipment, as well as traditional application on other piping and equipment.
2. Compliant with ASTM C165, C240, C303, C450, C552, C585, E136, E1461, and E84.
3. Service Temperature Range: -450°F to 900°F (-268°C to 482°C).
4. Thermal conductivity (K-value): 0.29 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C240.
6. Nominal density is 8 lbs./cu. ft. or greater.
7. Compressive Strength (block): Minimum of 90 psi to produce 5% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =0 ratings as tested per ASTM E84.

9. Manufacturers: Pittsburgh-Corning #Foamglas One or equal

C. **EI-C,** Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene:
1. Applications: Insulation of piping, fittings and equipment with thickness as required by local energy code.
2. Compliant with UL 181, ASTM C411, C518, C534, G21/C1338, G22, D1056 and E84. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
3. Service Temperature Range: -297°F to 220°F (-183°C to 105°C).
4. Thermal conductivity (K-value): 0.28 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive or factory self-seal system with lap seal tape.
9. Manufacturers: Armacel #AP Armaflex, Rubatex #K-Flex ECO, Aeroflex #Aerocel or equal.

D. **EI-D**, Rigid Fiberglass Board:
1. Applications: Rigid fiberglass insulation board for insulation of ducts and plenums, tanks, and walls with integral vapor barrier. Thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Glass fibers bonded with a thermosetting resin.
2. Compliant with ASTM C423, C553, C612, C665, C1101, C1136, C1338, E795 and E84.
3. Thermal conductivity (K-value): 0.25 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 0°F to 250°F (-18°C to 121°C) for faced board.
5. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
6. Vapor Retarder Jacket: Factory applied ASJ or FSK interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil.
7. Nominal density is 2.0 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: CertainTeed #CertaPro Commercial Board, Johns Manville #800 Series Spin-Glas, Knauf, Manson, Owens Corning or equal.

E. **EI-E**, Flexible Fiberglass Blanket:
1. Applications: Flexible insulation blanket for wrapping large pipes, tanks and equipment. Thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Glass or mineral fibers bonded with a thermosetting resin.
2. Compliant with ASTM C167, C177, C411, C518, C612, C665, C1136, C1338, C1393, E96 and E84.
3. Thermal conductivity (K-value): 0.24 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 35°F to 850°F (2°C to 454°C).
5. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
6. Vapor Retarder Jacket: Factory applied ASJ or FSK interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil.
7. Nominal density is 2.5 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: CertainTeed #CrimpWrap, Johns Manville #Micro-Flex, Knauf, Manson, Owens Corning or equal.

F. **EI-F**, Rigid High Temperature Mineral Fiber Board:
1. Applications: Rigid high temperature insulation board for insulation of equipment and tanks with thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Inorganic mineral fibers bonded with a thermosetting resin.
2. Compliant with ASTM C356, C447, C612, C665, C692, C795, C871, C1104 and E84.
3. Thermal conductivity (K-value): 0.25 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 0°F to 1200°F (-18°C to 650°C).
5. Water Vapor Absorption, % of volume: <1% (maximum) as tested per ASTM C1104.
6. Nominal density is 6 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Manufacturers: Johns Manville #MinWool-1260, Owens Corning Thermafiber #Industrial Board, Johns Manville, Knauf, Manson, Rockwool, CertainTeed or equal.

G. **EI-G**, Flexible High Temperature Mineral Fiber Blanket:
1. Applications: Flexible high temperature insulation blanket for tanks and equipment with thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Inorganic mineral fibers bonded with a thermosetting resin.
2. Compliant with ASTM C356, C447, C612, C665, C692, C795, C871, C1104 and E84.
3. Thermal conductivity (K-value): 0.25 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 0°F to 1200°F (-18°C to 650°C).
5. Water Vapor Absorption, % of volume: <1% (maximum) as tested per ASTM C1104.
6. Nominal density is 6 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Manufacturers: Owens Corning Thermafiber #Industrial Blanket, Johns Manville, Knauf, Manson, Rockwool, CertainTeed or equal.

H. **EI-H**, Rigid Closed-Cell Phenolic Foam:
1. Applications: Insulation of piping, tanks, and equipment with thickness as required by local energy code.
2. Compliant with ASTM C209, C518, C795, C1126, D1621, D1622, D2856, D6226 and E84.
3. Service Temperature Range: -290°F to 250°F (-178°C to 121°C).
4. Thermal conductivity (K-value): 0.18 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Vapor Retarder Jacket – straight sections: Factory applied ASJ with SSL.
6. Water Vapor Absorption, % of volume: <0.87% (maximum) as tested per ASTM C209.
7. Nominal density is 2.5 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: ITW Trymer #Supercel, Kingspan #Koolphen K, Resolco #Insul-phen or equal.

I. **EI-I**, Rigid Closed-Cell Polyisocyanurate Foam:
1. Applications: Rigid preformed insulation of piping, fittings, vessels, and equipment with thickness as required by local energy code. Not for use in return air plenums or ventilation ductworks.
2. Compliant with ASTM C272, C591, C755, C1136, C920, D6226, E96, and E84.
3. Service Temperature Range: -297°F to 300°F (-183°C to 149°C).
4. Thermal conductivity (K-value): 0.19 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Absorption, % of volume: 0.7 (maximum) as tested per ASTM C272.
6. Vapor Retarder Jacket: Saran 540/SSL or Mylar laminate.

7. Nominal density is 2 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤450 ratings as tested per ASTM E84. Not compliant for use in return air plenums.
9. Manufacturers: Trymer #2000 XP, Dyplast #ISO, HiTherm or equal.

J. **EI-J**, Rigid Extruded Polystyrene Foam Board:
1. Applications: Rigid board insulation for large outdoor tanks and vessels with thickness as required by local energy code. Not for use indoors.
2. Compliant with ASTM C203, C272, C518, C578, D121, D696, D1621, D2126, D2842 and E96.
3. Maximum Service Temperature: 165°F (75°C).
4. Thermal conductivity (K-value): 0.18 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =155 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive and provide field applied jacket system.
9. Manufacturers: Dow #Styrofoam or equal.

K. **EI-K**, Flexible Low Temperature Aerogel (Cold Fluid Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of low temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763 and E84.
3. Service Temperature Range: -200°F to 200°F (-129°C to 93°C).
4. Thermal conductivity (K-value): 0.12 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 10 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: Pacor #Cryogel X201 or equal.

L. **EI-L**, Flexible High Temperature Aerogel (Hot Fluid Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of high temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. Service Temperature Range: 32°F to 482°F (0°C to 250°C).
4. Thermal conductivity (K-value): 0.12 Btu•in./(hr•ft²•ºF), or less, at 212°F (100°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 10 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
9. Manufacturers: Pacor #Pryogel 2250.

M. **EI-M**, Flexible Extreme High Temperature Aerogel (High Temperature Exhaust Piping and Equipment):

1. Applications: High performance flexible insulation for specialty insulation of extreme high temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. Service Temperature Range: 32°F to 1200°F (0°C to 650°C).
4. Thermal conductivity (K-value): 0.16 Btu•in./(hr•ft²•ºF), or less, at 212°F (100°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 12.5 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
9. Manufacturers: Pacor #Pryogel XTE.

2.3 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   2. ASJ+: White, polypropylene-coated, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   3. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   4. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   5. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
   6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.4 JACKETING MATERIALS

A. Field Applied Jackets (For Indoor Applications):
   1. All longitudinal seams shall be located on bottom of pipes.
   2. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
   3. PVC Plastic:
      a. High-impact-resistant, UV-resistant PVC as tested per ASTM C553, C547, C665, C795, C1338, D1784, E96, C1136 and D3679.
      b. One piece molded type fitting covers and jacketing material.
      c. Adhesive: As recommended by jacket material manufacturer.
      d. Color: White.
      e. Thickness: 20 mil (0.5 mm), minimum.
      f. Service Temperature Range: 0°F to 150°F (-18°C to 66°C).
      g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
      h. Manufacturers: Johns Manville #Zeston 2000, Proto #LoSmoke, PIC Plastics, Proto Corporation, Speedline Corporation or equal.
   4. Aluminum Jacket:
      a. Comply with ASTM B209/B209M.
      b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
      c. Thickness: 0.016” thick sheet (minimum).
      d. Finish: Smooth or stucco embossed

e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
f. Longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8" or 1/2" stainless steel bands on 12" centers.
g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
h. Manufacturers: Pabco, Childers, RPR, ITW or equal.

5. Canvas Jacket:
   a. Cotton or fiberglass cloth.
   b. UL listed fabric treated with dilute fire retardant.
   c. Lagging adhesive per manufacturer.
   d. Manufacturers: GJC General, GLT Products, Foster #Mast-A-Fab, Childers #Chil-Glas No. 5 or equal.

B. Field Applied Jackets (For Outdoor Applications):
1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.
2. Secure stainless steel or aluminum jackets with 3/8" or 1/2" stainless steel bands on 12" centers and at each joint.
3. PVC Jacket: Not allowed for outdoor applications.
4. Canvas Jacket: Not allowed for outdoor applications.
5. Aluminum Jacket:
   a. Comply with ASTM B209/B209M.
   b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
   c. Thickness: 0.016" thick sheet (minimum).
   d. Finish: Smooth, stucco embossed or corrugated surface.
   e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
   f. Longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8" or 1/2" stainless steel bands on 12" centers.
   g. Manufacturers: Pabco, Childers, RPR, ITW or equal.
6. Self-Adhesive Aluminum Jacket:
   a. Comply with ASTM D774, C1338, C1371, E96, and D882.
   b. Thickness: 56 mils (minimum).
   c. Multi-ply UV-resistant aluminum foil/polymer laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
   d. Weight: 0.3 lbs./sf, minimum.
   e. Service Temperature Range: -15°F to 160°F (-26°C to 71°C).
   f. Manufacturers: Polyguard Products #Alumaguard or equal.
7. Stainless Steel Jacket:
   a. Comply with ASTM A240 and A666.
   b. Stainless steel alloy T-304 or T-316. T-316 shall be used in corrosive environments including close proximity to coast.
   c. Thickness: 0.016" thick sheet (minimum).
   d. Dull Finish: Smooth, stucco embossed or corrugated surface.
   e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
   f. Longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8" or 1/2" stainless steel bands on 12" centers.
   g. Manufacturers: Pabco, Childers, RPR, ITW or equal.

C. Removable Covers:
1. Provide removable covers on indoor pumps, valves, air separators, air vent fittings, flanges, strainers, traps, etc., where periodic maintenance or removal of insulation is required.
   a. Pre-molded insulation covers:
      1) Cold Systems: Provide PVC covers over insulated elbows, fittings and flanges.

2) Cold Systems: Provide flexible closed cell foam or removable cloth insulating blankets for valves, pumps and strainers.
3) Hot Systems: Provide PVC covers over insulated elbows, fittings and flanges.
4) Hot Systems: Provide removable cloth insulating blankets on valves, pumps, and strainers.

b. Removable cloth insulating blankets:
1) Service Operating Temperature: 0-350°F.
2) Jacket and Liner: silicon or teflon impregnated mineral wool cloth.
3) Liner Reinforcement: stainless steel mesh cloth.
4) Insulation: Fiberglass matt or Pacor #Aerogel, 2" thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
5) Fastening: 2" Nomex Velcro or 1" straps and stainless steel D-rings or 12-gage stainless steel hooks and stainless steel wire.
6) Thread: Kevlar/stainless steel thread.
7) Outdoor Applications: Jacket shall be UV and ozone resistant with Velcro attachment.
8) Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, Alpha or equal.

2.5 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304

2.6 ADHESIVES (NOTE TO EDITOR: FOR SECURING INSULATION TO SUBSTRATE.)

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

B. Calcium Silicate Adhesive:
1. Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 1200°F (10 to 649°C).
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Childers Brand #CP-97, Johns Manville #CalBond Gold, Marathon Industries #290, Foster Brand #81-27, Mon-Eco Industries #22-30, Vimasco Corporation #760 or equal.

C. Cellular-Glass Adhesive:
1. Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200°F (minus 73 to plus 93°C).
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Foster Brand #81-84 or equal.

D. Phenolic and Polyisocyanurate Adhesive:
1. Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300°F (minus 59 to plus 149°C).
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Childers Brand #CP-96, Foster Brand #81-33 or equal.

E. Flexible Elastomeric and Polyolefin Adhesive:
   1. Comply with MIL-A-24179A, Type II, Class I.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Aeroflex USA, Inc.; Aeroseal, Armacell LLC; Armaflex #520 Adhesive, Foster Brand #85-75, K-Flex USA #R-373 Contact Adhesive or equal.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Manufacturers: Childers Brand #CP-127, Eagle Bridges - Marathon Industries #225, Foster Brand #85-60/85-70, Mon-Eco Industries, Inc.#22-25 or equal.

G. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Manufacturers: Childers Brand #CP-82, Eagle Bridges - Marathon Industries #225, Foster Brand #85-50, Mon-Eco Industries, Inc.#22-25 or equal.

H. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Manufacturers: Dow Corning Corporation #739, Dow Silicone, Johns Manville #Zeston Perma-Weld, CEEL-TITE #Solvent Welding Adhesive, P.I.C. Plastics, Inc. #Welding Adhesive, Speedline Corporation #Polyco VP Adhesive or equal.

2.7 MASTICS (NOTE TO EDITOR: FOR COATING OVER INSULATION.)

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based for indoor use.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43 mil (1.09 mm) dry film thickness.
   2. Service Temperature Range: -20°F to 180°F (-29 to 82°C).
   3. Vapor Safe Coating: Shall meet requirements of LEED IEQ Low-Emitting Materials. VOC 33 g/l, less water and exempt solvents.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   5. Color: White.
   6. Manufacturers: Foster Brand #30-80/30-90, Vimasco Corporation #749 or equal.

C. Vapor-Barrier Mastic: Solvent based for outdoor use.
   1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30 mil (0.8 mm) dry film thickness.
   2. Service Temperature Range: -50°F to 220°F (-46 to 104°C).
   3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   4. Color: White.
   5. Manufacturers: Childers Brand #Encacel X CP-40, Eagle Bridges - Marathon Industries #570, Foster Brand #60-95/60-96 or equal.

D. Breather Mastic: Water based for indoor and outdoor use.
   1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625 inch (1.6 mm) dry film thickness.
   2. Service Temperature Range: -20°F to 180°F (-29 to 82°C).

3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.
5. Manufacturers: Childers Brand #CP-10/CP-11, Eagle Bridges - Marathon Industries #550, Foster Brand #46-50, Mon-Eco Industries, Inc. #55-50, Vimasco Corporation #WC-1/WC-5 or equal.

2.8 LAGGING ADHESIVES (NOTE TO EDITOR: FOR SECURING JACKET OVER INSULATION.)

A. Adhesives shall be compatible with insulation materials, jackets, and substrates.
1. Comply with MIL-A-3316C, Class I, Grade.
2. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to 180°F (-18 to 82°C).
5. Color: White.
6. Manufacturers: Childers Brand #CP-50 AHV2, Foster Brand #30-36, Vimasco Corporation #713/714 or equal.

2.9 SEALANTS (NOTE TO EDITOR: FOR SEALING AT JOINTS.)

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate.
a. Manufacturers: Childers Brand #CP-76, Marathon Industries#405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05, Pittsburgh Corning Corporation #Pittseal 444 or equal.
2. Joint Sealants for Polystyrene.
a. Manufacturers: Childers Brand #CP-70, Marathon Industries #405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05 or equal.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: -100 to 300°F (-73 to 149°C).
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Shall be compliant with requirements of LEED IEQ Low-Emitting Materials.

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76, Eagle Bridges - Marathon Industries #405, Foster Brand #95-44, Mon-Eco Industries, Inc. #44-05 or equal.

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76 or equal.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
   7. Manufacturers: ABI, Ideal Tape Division #428 AWF ASJ, Avery Dennison Corporation #Fasson 0836, Compac Corporation #105, 3M Venture Tape #1540 CW Plus/1542 CW Plus/1542 CW Plus/SQ or equal.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
   7. Manufacturers: ABI Tape #491 AWF FSK, Avery Dennison Corporation #Fasson 0827, Compac Corporation #110 and 111, 3M Venture Tape #1525 CW NT/1528 CW/1528 CW/SQ or equal.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches (50 mm).
   2. Thickness: 6 mils (0.15 mm).
   3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
   6. Manufacturers: ABI Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS or equal.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
   6. Manufacturers: ABI Tape #488 AWF, Avery Dennison Corporation #Fasson 0800, Compac Corporation #120, 3M Venture Tape #3520 CW or equal.

2.11 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
   2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
   3. Manufacturers: ITW Insulation Systems, Gerrard, RPR or equal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins:
      a. Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated.
      b. Manufacturers: AGM Industries #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins:
      a. Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38 mm) galvanized carbon-steel washer.
      b. Manufacturers: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers:
      a. Baseplate welded to projecting spindle capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
      b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
      c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated.
      d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
      e. Manufacturers: AGM Industries, Inc. #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners #Spindle or equal.
   4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers:
      a. Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
      b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
      c. Spindle: Nylon, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
      d. Adhesive as recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
      e. Manufacturers: GEMCO #Nylon Hangers, Midwest Fasteners #Nylon Insulation Hangers or equal.
   5. Self-Sticking-Base Insulation Hangers:
      a. Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
      b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
      c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12 gauge, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated.
      d. Adhesive-backed base with a peel-off protective cover.
      e. Manufacturers: AGM Industries, Inc. #Tactoo Self-Adhering Insul-Hangers, GEMCO #Peel & Press, Midwest Fasteners #Self Stick equal.
   6. Insulation-Retaining Washers:
      a. Self-locking washers formed from 0.015 inch (0.41 mm) thick, galvanized-steel, aluminum or stainless steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
      b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

c. Manufacturers: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.

7. Nonmetal Insulation-Retaining Washers:
   a. Self-locking washers formed from 0.016 inch (0.41 mm) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   b. Manufacturers: GEMCO, Midwest Fasteners or equal.

C. Staples: Outward-clinching insulation staples, nominal 0.75 inch (19 mm) wide, stainless steel or Monel.

D. Wire: 0.062 inch (1.6 mm) soft-annealed, stainless steel.
   1. Manufacturers: C&F Wire Products or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature ranging from 140°F to 300°F (60°C to 149°C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature ranging from 32°F to 300°F (0°C to 149°C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

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

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

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3” (75 mm) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) on center.
   3. Overlap jacket longitudinal seams at least 1-1/2” (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2” (50 mm) on center. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

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

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

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4” (100 mm) beyond damaged areas. Adhere, staple, and seal patches like butt joints.

O. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   4. Manholes.
   5. Handholes.
   6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
   2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   3. Protect exposed corners with secured corner angles.
   4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      a. Do not weld anchor pins to ASME-labeled pressure vessels.
      b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16” (400 mm) on center in both directions.
      d. Do not over compress insulation during installation.
      e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
      f. Impale insulation over anchor pins and attach speed washers.
      g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
   5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
   6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles or breather springs. Place one circumferential girdle around equipment approximately 6” (150 mm) from each end. Install wire or cable between two circumferential girdles 12” (300 mm) on center. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48” (1200 mm) on center. Use this network for securing insulation with tie wire or bands.
   7. Stagger joints between insulation layers at least 3” (75 mm).
   8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
   9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
   10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:
   1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6” (150 mm) centers, starting at corners. Install 3/8” (10 mm) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   2. Fabricate boxes from galvanized steel, aluminum or stainless steel, at least 0.040 inch (1.0 mm) thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:
   1. Secure single-layer insulation with stainless-steel bands at 12” (300 mm) intervals and tighten bands without deforming insulation material.
   2. Install two-layer insulation with joints tightly butted and staggered at least 3” (75 mm). Secure inner layer with wire spaced at 12” (300 mm) intervals. Secure outer layer with stainless-steel bands at 12” (300 mm) intervals.
   3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1” (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF PHENOLIC INSULATION

A. Secure single-layer insulation with stainless-steel bands at 12” (300 mm) intervals and tighten bands without deforming insulation materials.

B. Install two-layer insulation with joints tightly butted and staggered at least 3” (75 mm). Secure inner layer with 0.062” (1.6 mm) wire spaced at 12” (300 mm) intervals. Secure outer layer with stainless-steel bands at 12” (300 mm) intervals.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2” (50 mm) overlap at seams and joints.
   2. Embed glass cloth between two 0.062” (1.6 mm) thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2” (38 mm) laps at longitudinal seams and 3” (75 mm) wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

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

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

E. Where PVDC jackets are indicated, install as follows:
   1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference less than 34” (860 mm). A 34” (860 mm) circumference limit allows for 2” (50 mm) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fish mouthing," and use PVDC tape along lap seal to secure joint.
   2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 125% circumferences to avoid damage to tape edges.

3.8 FINISHES

A. Equipment Insulation with ASJ+, Glass-Cloth or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 for Sections "Exterior Painting” and “Interior Painting”.
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

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

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

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

3.9 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

H. TABLE 1: EQUIPMENT INSULATION TYPE REQUIRED.
   1. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Increase thickness by 1/2” (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior “K” factors. Refer to “PART 2-PRODUCTS” for characteristics of each insulation material listed below.

EQUIIPMENT INSULATION INDEX	
INSULATION KEY CODE	INSULATION TYPE
EI-A	Rigid Hydrous Calcium Silicate
EI-B	Rigid Closed-Cell Cellular Glass
EI-C	Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene
EI-D	Rigid Fiberglass Board
EI-E	Flexible Fiberglass Blanket
EI-F	Rigid High Temperature Mineral Fiber Board
EI-G	Rigid High Temperature Mineral Fiber Blanket
EI-H	Rigid Closed-Cell Phenolic Foam
EI-I	Rigid Closed-Cell Polyisocyanurate Foam
EI-J	Rigid Extruded Polystyrene Foam Board
EI-K	Flexible Low Temperature Aerogel
EI-L	Flexible High Temperature Aerogel
EI-M	Flexible Extreme High Temperature Aerogel

TABLE 1: EQUIPMENT INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Insulated pipes, equipment, fittings, valves, etc. at pipe hangers and supports with saddles or 360° shields.	**EI-A**	Same thickness as adjoining pipe insulation
Chiller cold surfaces: condenser, evaporator, heat recovery bundles, suction piping, compressor inlets, water boxes, and nozzles.	**EI-C,D,F,H,I**	1” (25 mm)
Heat exchanger for cooling service.	**EI-C,D,F,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Heat exchanger for heating service.	**EI-D,F,H,I**	3” (75 mm)
	EI-L	1.5” (38 mm)
Steam to hot water converter.	**EI-D,F**	4” (100 mm)
	EI-L	2” (50 mm)
Chilled water pump.	**EI-C,D,F,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Condenser water pump (outdoors).	**EI-C,D,F,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Heating hot water pump.	**EI-D,F,H,I**	3” (75 mm)
	EI-L	1.5” (38 mm)
Heat recovery pump.	**EI-D,F,H,I**	2” (50 mm)
	EI-L	1” (25 mm)
Chilled water expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Condenser water expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Hot water expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Heat recovery system expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Chilled and condenser water air separator	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Heating water air separator.	**EI-C,D,E,F,G,H,I**	3” (75 mm)
	EI-L	1.5” (38 mm)
Cold thermal storage tank (indoors).	**EI-C,D,E,F,G,H,I**	3” (75 mm)
	EI-K	1.5” (38 mm)
Cold thermal storage tank (outdoors).	**EI-H,I,J**	3” (75 mm)
	EI-K	1.5” (75 mm)
Deaerator.	**EI-D,E,F,G,H,I**	3” (75 mm)
	EI-L	1.5” (38 mm)
Steam condensate pump and boiler feedwater pump.	**EI-D,E,F,G,H,I**	3” (75 mm)
	EI-L,M	1.5” (38 mm)
Steam condensate tank and receiver.	**EI-D,E,F,G,H,I**	3” (75 mm)
	EI-L,M	1.5” (38 mm)
Steam flash tank, flash separator, moisture separator, blow off tank.	**EI-D,E,F,G,H,I**	3” (75 mm)
	EI-L,M	1.5” (38 mm)
Outdoor, aboveground, heated, fuel-oil storage tank.	**EI-B**	3” (75 mm)
	EI-D,E,F,G,H,I	2” (50 mm)

TABLE 1: EQUIPMENT INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Insulated pipes, equipment, fittings, valves, etc. at pipe hangers and supports with saddles or 360° shields.	**EI-A**	Same thickness as adjoining pipe insulation
	EI-J	1.5” (38 mm)
Buried cold water piping and tanks.	**EI-B**	2” (50 mm)
Breeching, flues and connectors.	**EI-A**	4” (100 mm). Thickness is based on desired exterior temperature defined by code.
	EI-F,G	3” (75 mm)
	EI-L,M	2” (50 mm)
Generator engine exhaust piping, including flanges, fittings, mufflers, filters, etc.	**EI-A**	4” (100 mm). Thickness is based on desired exterior temperature defined by code.
	EI-O	2” (50 mm)
Generator engine exhaust flexible piping fittings	**EI-G**	3” (75 mm)
	EI-M	2” (50 mm)

3.10 EQUIPMENT INSULATION JACKET SCHEDULE

A. All insulation jackets shall be applied to protect the underlying insulation as scheduled above, providing protection both from environmental and physical conditions.

B. TABLE 2: INDOOR FIELD APPLIED EQUIPMENT INSULATION JACKETS

TABLE 2:
INDOOR EQUIPMENT FIELD APPLIED INSULATION JACKET

SERVICE	JACKET TYPE	THICKNESS OPTIONS	FINISH OPTIONS	CORRUGATION OPTIONS
Concealed equipment.	PVC	20 or 30 mils		
	Aluminum	0.016, 0.020, 0.024 or 0.032 inch	Smooth, corrugated, embossed	
	Stainless Steel	0.010, 0.016, 0.020, 0.024 inch	Smooth, corrugated, embossed	
Exposed equipment up to 48 inches in diameter or with flat surfaces to 72 inches.	PVC	20 or 30 mils		
	Aluminum	0.016, 0.020, 0.024 or 0.032 inch	Smooth, corrugated, embossed	
	Stainless Steel (304 or 316 type)	0.010, 0.016, 0.020, 0.024 inch	Smooth, corrugated, embossed	
Exposed equipment larger than 48 inches in diameter or with flat surfaces greater than 72 inches.	Aluminum	0.032 inch 0.040 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep 4 x 1 inch
	Stainless Steel (304 or 316 type)	0.020 inch 0.024 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep 4 x 1 inch

1. Notes:
2. Install jacket over insulation material. For insulation with factory applied jacket, install the field applied jacket over the factory applied jacket.
3. If more than one material is listed, selection from materials listed is Contractor's option.

C. TABLE 3: OUTDOOR FIELD APPLIED EQUIPMENT INSULATION JACKETS

TABLE 3: OUTDOOR EQUIPMENT FIELD APPLIED INSULATION JACKET				
SERVICE	JACKET TYPE	THICKNESS OPTIONS	FINISH OPTIONS	CORRUGATION OPTIONS
Concealed equipment	PVC	20 or 30 mils		
	Aluminum	0.016 inch, 0.020inch, 0.024inch, 0.032 inch 0.040 inch	Smooth, Corrugated, Embossed	
	Stainless Steel	0.010 inch 0.016 inch 0.020 inch 0.024 inch	Smooth, Corrugated, Embossed	
Exposed equipment up to 48 inches in diameter or with flat surfaces to 72 inches.	Aluminum	0.016, 0.020, 0.024 or 0.032 inch	Smooth, Corrugated, Embossed	
	Stainless Steel (304 or 316 type)	0.010 inch 0.016 inch 0.020 inch 0.024 inch	Smooth, Corrugated, Embossed	
Exposed equipment larger than 48 inches in diameter or with flat surfaces greater than 72 inches.	Aluminum	0.032 inch 0.040 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep x 4 x 1 inch
	Stainless Steel (304 or 316 type)	0.020 inch 0.024 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep x 4 x 1 inch

Notes:
1. Install jacket over insulation material. For insulation with insulation with factory applied jacket, install the field applied jacket over the factory applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.

END OF SECTION 230716

SECTION 230719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:
   1. Piping Insulation:
      a. Piping Insulation.
      b. Insulation Jackets.
      c. Removable Covers.
   2. Acoustic piping wrap
   3. Section includes the following HVAC piping systems:
      a. Heat recovery piping.
      b. Process piping.
      c. Valves, pumps, air separators, strainers and fittings in insulated piping systems.
      d. Refrigerant hot gas and suction piping.

B. Types of mechanical insulation specified in this Section include the following:
   1. Glass fiber.
   2. Mineral wool.
   3. Closed cell phenolic.
   4. Polyisocyanurate.
   5. Calcium silicate.
   6. Cellular glass.
   7. Flexible elastomeric closed cell foam.
   8. Aerocel.
   9. Insulation jackets.
   10. Removable covers.
   11. Insulation accessories.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Division 22: Plumbing.

B. Section 230500: Basic HVAC Materials and Methods.

C. Section 232113: Hydronic Piping, Valves and Specialties.

1.3 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 34°F (1°C), as stated in ASHRAE Fundamentals under 99% column for winter design conditions.

I. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.4 INSULATION INDUSTRY DEFINITIONS

A. Third Party Independent Product sustainable certification: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.
   1. UL GREENGUARD
   2. Scientific Certification Systems (SCS)

B. EPA: Environmental Protection Agency.

C. WHO: World Health Organization.

D. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film layer leaving no paper exposed.

E. ASJ: All Service Jacket (no outer film).

F. SSL+: Self-Sealing Lap with Advanced Closure System.

G. SSL: Self-Sealing Lap.

H. FSK: Foil Scrim Kraft; jacketing.

I. FSP: Foil Scrim Polyethylene jacketing

J. PSK: Poly Scrim Kraft; jacketing.

K. FHC: Fire Hazard Classification

L. PVC: Polyvinyl Chloride.

M. Bio based Binder Technology: binder systems based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. Biobased Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

N. UL GREENGUARD Gold Certification: Certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in environments such as schools and healthcare facilities. It is referenced by the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

O. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

P. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

Q. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

R. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

S. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to document they are free of Red List chemicals and materials. The Red List represents the "worst in class" materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

T. Underwriter's Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

U. UL Environment Claims Validation (ECV): service and label tests a manufacturer's product and validates that the environmental claims they make in their marketing and packaging materials are factual. This ECV service enables products to qualify for LEED® MR Credit 4 Recycled Content LEED V-4 Building product disclosure and optimization – sourcing of raw materials.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
   1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
      a. B209: Specification for Aluminum and Aluminum-Alloy Sheet and Plat.
      b. C165: Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
      c. C168: Provides standard terminology for thermal insulation.
      d. C177: Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
      e. C195: Specification for Mineral Fiber Thermal Insulating Cement.
      f. C196: Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
      g. C302: Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
      h. C303: Test Method for Density of Preformed Block-Type Thermal Insulation.
      i. C305: Test for Thermal Conductivity of Pipe Insulation.
      j. C335: Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation.
      k. C356: Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
      l. C411: Test for Hot-Surface Performance of High Temperature Thermal Insulation.
      m. C423: Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
      n. C449: Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
      o. C518: Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
      p. C533:Specification for Calcium Silicate Block and Pipe Thermal Insulation.
      q. C534: Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
      r. C547: Specification for Mineral Fiber Pipe Insulation.
      s. C552: Specification for Cellular Glass Block and Pipe Thermal Insulation.
      t. C553: Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).

u. C592: Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
v. C612: Specification for Mineral Fiber Block and Board Thermal Insulation.
w. C755: Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation.
x. C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
y. C916: Standard Specification for Adhesives for Duct Thermal Insulation.
z. C921: Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
aa. C1071: Standard Specification for Thermal and Acoustical Insulation.
bb. C1104: Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
cc. C1136: Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
dd. C1338: Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
ee. C1393: Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.
ff. C1617-05: Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals
gg. E84: Test Method for Surface Burning Characteristics of Building Materials.
hh. E119: Test for Fire Resistance.
ii. G21: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
jj. G22: Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90: Energy Conservation in New Building Design.
3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 255: Test Methods, Surface Burning Characteristics of Building Materials.

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

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method where installed in a return air plenum or in a ventilation intake or mechanical room. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Corrosiveness: Passes ASTM C1617-05, Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

G. Sustainable Project Requirements:
   1. Formaldehyde Free: Third party certified with UL Environment or Scientific Certification Systems (SCS) Validation.
   2. Biosoluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products (EUCEB).
   3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation Products, provide materials complying with the testing and products requirements of GREENGUARD Certification.

1.6 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9).
   2. Octabrominated diphenyl ether (CAS#32536-52-0).
   3. Decabrominated diphenyl ether (CAS#1163-19-50).

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Comply with requirements in "Part 3, Table 1: Piping Services, Fluid Temperature, and Insulation Type Required" for application of insulating materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall meet UL GREENGUARD certification standards for low-emitting products.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

A. Each insulation material has been provided a descriptive key code, such as **PI-A**, to simplify the organization and application of materials in following sub-sections.

E. Acceptable manufacturers include Knauf Insulation, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Aeroflex, Armacell, Reflectix, Pacor or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each product classification.

2.2 PIPE INSULATIONS (IDENTIFIED BY KEY CODE **PI** BELOW AND IN TABLE 1)

A. **PI-A,** Preformed Mineral Wool or Fiberglass:
1. Materials: Mineral wool or fiberglass bonded with a thermosetting resin. Product to be validated GREENGUARD Gold for low VOC's. In addition, pipe insulation to have a validated EPD from UL Environment or Scientific Certification Systems.
2. Applications: Insulation of piping and fittings with thickness as required by local energy code.
3. Compliant with ASTM C335, C356, C411, C447, C547, C585, C795, C1045, C1104 E96, and E84.
4. Compliant with ASTM C547 Type I, 850°F (454°C) or Type IV, 1000°F (538°C).
5. Thermal conductivity (K-value): 0.24 Btu•in./(hr•ft²•ºF) or less, at 100°F (38°C). Thickness as required to meet energy code requirements.
6. Service Temperature Range: 0°F to 850°F (-18°C to 454°C).
7. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
8. Vapor Retarder Jacket: Factory applied ASJ or ASJ+ with SSL, white kraft paper interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips.
9. Nominal density is 2.5 lbs./cu. ft., greater.
10. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
11. Manufacturers: Knauf #ECOSE Earthwool 1000°, Johns Manville #Micro-Lok or #Micro-Lok, Owens Corning, CertainTeed, Manson or equal.

B. **PI-D,** Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene:
1. Applications: Insulation of piping and fittings with thickness as required by local energy code.
2. Compliant with UL 181, ASTM C411, C518, C534, G21/C1338, G22, D1056 and E84.
3. Service Temperature Range: -297°F to 220°F (-183°C to 105°C).
4. Thermal conductivity (K-value): 0.28 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive or factory self-seal system with lap seal tape.
9. Manufacturers: Armacell #AP Armaflex, Rubatex #K-Flex ECO, Aeroflex #Aerocel or equal.

C. **PI-C,** Rigid Closed-Cell Phenolic Foam:
1. Applications: Insulation of piping and fittings with thickness as required by local energy code.
2. Compliant with ASTM C209, C518, C795, C1126, D1621, D1622, D2856, D6226 and E84.
3. Service Temperature Range: -290°F to 250°F (-178°C to 121°C).
4. Thermal conductivity (K-value): 0.18 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Vapor Retarder Jacket – straight sections: Factory applied ASJ with SSL.
6. Water Vapor Absorption, % of volume: <0.87% (maximum) as tested per ASTM C209.
7. Nominal density is 2.5 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.

9. Manufacturers: ITW Trymer #Supercel, Kingspan #Koolphen K, Resolco #Insul-phen or equal.

D. **PI-D,** Rigid Closed-Cell Polyisocyanurate Foam:
1. Applications: Rigid preformed insulation of piping, fittings, vessels, and equipment with thickness as required by local energy code. Not for use in return air plenums or ventilation ductworks.
2. Compliant with ASTM C272, C591, C755, C1136, C920, D6226, E96, and E84.
3. Service Temperature Range: -297°F to 300°F (-183°C to 149°C).
4. Thermal conductivity (K-value): 0.19 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Absorption, % of volume: 0.7 (maximum) as tested per ASTM C272.
6. Vapor Retarder Jacket: Saran 540/SSL or Mylar laminate.
7. Nominal density is 2 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and **Smoke Developed Index ≤450** ratings as tested per ASTM E84. Not compliant for use in return air plenums.
9. Manufacturers: Trymer #2000 XP, Dyplast #ISO, HiTherm or equal.

E. **PI-E,** Rigid Preformed Hydrous Calcium Silicate:
1. Applications: High temperature insulation for piping and equipment and for placement at piping hangers and supports.
2. Compliant with ASTM C165, C302, C356, C447, C533, C665, C1338 and E84.
3. Maximum Service Temperature: 1200°F (650°C).
4. Thermal conductivity (K-value): 0.389 Btu•in./(hr•ft²•ºF) or less, at 200°F (93°C). Thickness as required to meet energy code requirements.
5. Nominal density is 14 lbs./cu. ft. or greater.
6. Compressive Strength (block): Minimum of 100 psi to produce 5% compression as tested per ASTM C165.
7. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =0 ratings as tested per ASTM E84.
8. Tie Wire: 16-gauge stainless steel with twisted ends on maximum 12” centers.
9. Product must contain corrosion inhibiting chemistry.
10. Manufacturers: Johns Manville Industrial Insulation Group #Thermo-12 Gold or equal.

F. **PI-F,** Rigid Closed-Cell Cellular Glass:
1. Applications: Rigid closed cell glass impermeable to water and water vapor for insulating buried piping, as well as traditional application on other piping and equipment.
2. Compliant with ASTM C165, C240, C303, C450, C552, C585, E136, E1461, and E84.
3. Service Temperature Range: -450°F to 900°F (-268°C to 482°C).
4. Thermal conductivity (K-value): 0.29 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C240.
6. Nominal density is 8 lbs./cu. ft. or greater.
7. Compressive Strength (block): Minimum of 90 psi to produce 5% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =0 ratings as tested per ASTM E84.
9. Manufacturer: Pittsburgh-Corning #Foamglas One or equal.

G. **PI-G**, Flexible Low Temperature Aerogel (Cold Fluid Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of low temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763 and E84.
3. Service Temperature Range: -200°F to 200°F (-129°C to 93°C).

4. Thermal conductivity (K-value): 0.12 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 10 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturer: Pacor #Cryogel X201 or equal.

H. **PI-H**, Flexible High Temperature Aerogel (Hot Fluid Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of high temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. Service Temperature Range: 32°F to 482°F (0°C to 250°C).
4. Thermal conductivity (K-value): 0.12 Btu•in./(hr•ft²•ºF), or less, at 212°F (100°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 10 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
9. Manufacturer: Pacor #Pryogel 2250.

I. **PI-I**, Flexible Extreme High Temperature Aerogel (High Temperature Exhaust Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of extreme high temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. Service Temperature Range: 32°F to 1200°F (0°C to 650°C).
4. Thermal conductivity (K-value): 0.16 Btu•in./(hr•ft²•ºF), or less, at 212°F (100°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 12.5 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
9. Manufacturer: Pacor #Pryogel XTE.

2.3 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ+: White, polypropylene-coated, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
3. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

4. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
5. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.4 JACKETING MATERIALS

A. Field Applied Jackets (For Indoor Applications):
   1. All longitudinal seams shall be located on bottom of pipes.
   2. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
   3. PVC Plastic:
      a. High-impact-resistant, UV-resistant PVC as tested per ASTM C553, C547, C665, C795, C1338, D1784, E96, C1136 and D3679.
      b. One piece molded type fitting covers and jacketing material.
      c. Adhesive: As recommended by jacket material manufacturer.
      d. Color: White.
      e. Thickness: 20 mil (0.5 mm), minimum.
      f. Service Temperature Range: 0°F to 150°F (-18°C to 66°C).
      g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
      h. Manufacturers: Johns Manville #Zeston 2000, Proto #LoSmoke or equal by PIC Plastics, Proto Corporation, Speedline Corporation or equal.
   4. Aluminum Jacket:
      a. Comply with ASTM B209/B209M.
      b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
      c. Thickness: 0.016” thick sheet (minimum).
      d. Finish: Smooth or stucco embossed
      e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
      f. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
      g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
      h. Manufacturers: Pabco, Childers, RPR, ITW or equal.
   5. Canvas Jacket:
      a. Cotton or fiberglass cloth.
      b. UL listed fabric treated with dilute fire retardant.
      c. Lagging adhesive per manufacturer.
      d. Manufacturers: GJC General, GLT Products, Foster #Mast-A-Fab, Childers #Chil-Glas No. 5 or equal.

B. Field Applied Jackets (For Outdoor Applications):
   1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.
   2. Secure stainless steel or aluminum jackets with 3/8” or 1/2” stainless steel bands on 12” centers and at each joint.
   3. PVC Jacket: Not allowed for outdoor applications.
   4. Canvas Jacket: Not allowed for outdoor applications.
   5. Aluminum Jacket:
      a. Comply with ASTM B209/B209M.
      b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
      c. Thickness: 0.016” thick sheet (minimum).
      d. Finish: Smooth, stucco embossed or corrugated surface.
      e. Color: White with surface emittance of 0.8, or greater, per ASTM C1371 for piping and equipment exposed to sunlight.

f. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
g. Longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8" or 1/2" stainless steel bands on 12" centers.
h. Manufacturers: Pabco, Childers, RPR, ITW or equal.

6. Self-Adhesive Aluminum Jacket:
   a. Comply with ASTM D774, C1338, C1371, E96 and D882.
   b. Thickness: 56 mils (minimum).
   c. Multi-ply UV-resistant aluminum foil/polymer laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
   d. Color: White with surface emittance of 0.8, or greater, per ASTM C1371 for piping and equipment exposed to sunlight.
   e. Weight: 0.3 lbs./sf, minimum.
   f. Service Temperature Range: -15°F to 160°F (-26°C to 71°C).
   g. Manufacturer: Polyguard Products #Alumaguard or equal.
7. Stainless Steel Jacket:
   a. Comply with ASTM A240 and A666.
   b. Stainless steel alloy T-304 or T-316. T-316 shall be used in corrosive environments including close proximity to coast.
   c. Thickness: 0.016" thick sheet (minimum).
   d. Dull Finish: Smooth, stucco embossed or corrugated surface.
   a. Color: White with surface emittance of 0.8, or greater, per ASTM C1371 for piping and equipment exposed to sunlight.
   e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
   f. Longitudinal slip joints and 2" laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8" or 1/2" stainless steel bands on 12" centers.
   g. Manufacturers: Pabco, Childers, RPR, ITW or equal.

C. Removable Covers:
1. Provide removable covers on indoor pumps, valves, air separators, air vent fittings, flanges, strainers, traps, etc., where periodic maintenance or removal of insulation is required.
   a. Pre-molded insulation covers:
      1) Cold Systems: Provide PVC covers over insulated elbows, fittings and flanges.
      2) Cold Systems: Provide flexible closed cell foam or removable cloth insulating blankets for valves, pumps and strainers.
      3) Hot Systems: Provide PVC covers over insulated elbows, fittings and flanges.
      4) Hot Systems: Provide removable cloth insulating blankets on valves, pumps, and strainers.
   b. Removable cloth insulating blankets:
      1) Service Operating Temperature: 0-350°F.
      2) Jacket and Liner: silicon or teflon impregnated mineral wool cloth.
      3) Liner Reinforcement: stainless steel mesh cloth.
      4) Insulation: Fiberglass matt or Pacor #Aerogel, 2" thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
      5) Fastening: 2" Nomex Velcro or 1" straps and stainless steel D-rings or 12-gage stainless steel hooks and stainless steel wire.
      6) Thread: Kevlar/stainless steel thread.
      7) Outdoor Applications: Jacket shall be UV and ozone resistant with Velcro attachment.
      8) Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, Alpha or equal.

2.5 ADHESIVES

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

B. Calcium Silicate Adhesive:
   1. Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 1200°F (10 to 649°C).
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Childers Brand #CP-97, Johns Manville #CalBond Gold, Marathon Industries #290, Foster Brand #81-27, Mon-Eco Industries #22-30, Vimasco Corporation #760 or equal.

C. Cellular-Glass Adhesive:
   1. Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200°F (minus 73 to plus 93°C).
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Foster Brand #81-84 or equal.

D. Phenolic and Polyisocyanurate Adhesive:
   1. Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300°F (minus 59 to plus 149°C).
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Childers Brand #CP-96, Foster Brand #81-33 or equal.

E. Flexible Elastomeric and Polyolefin Adhesive:
   1. Comply with MIL-A-24179A, Type II, Class I.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Armaflex #520 Adhesive, Foster Brand #85-75, K-Flex USA #R-373, Aeroflex USA, Aeroseal, Armacell, or equal.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Manufacturers: Childers Brand #CP-127, Eagle Bridges - Marathon Industries #225, Foster Brand #85-60/85-70, Mon-Eco Industries, Inc.#22-25 or equal.

G. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Manufacturers: Childers Brand #CP-82, Eagle Bridges - Marathon Industries #225, Foster Brand #85-50, Mon-Eco Industries, Inc.#22-25 or equal.

H. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Manufacturers: Dow Corning Corporation #739, Dow Silicone, Johns Manville #Zeston Perma-Weld, CEEL-TITE #Solvent Welding Adhesive, P.I.C. Plastics, Inc. #Welding Adhesive, Speedline Corporation #Polyco VP Adhesive or equal.

2.6 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based for indoor use.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
   3. Vapor Safe Coating: Shall meet requirements of LEED IEQ Low-Emitting Materials. VOC 33 g/l, less water and exempt solvents.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   5. Color: White.
   6. Manufacturers: Foster Brand #30-80/30-90, Vimasco Corporation #749 or equal.

C. Vapor-Barrier Mastic: Solvent based for outdoor use.
   1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
   2. Service Temperature Range: Minus 50 to plus 220°F (Minus 46 to plus 104°C).
   3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   4. Color: White.
   5. Manufacturers: Childers Brand #Encacel X CP-40, Eagle Bridges - Marathon Industries #570, Foster Brand #60-95/60-96 or equal.

D. Breather Mastic: Water based for indoor and outdoor use.
   1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
   3. Solids Content: 60 percent by volume and 66 percent by weight.
   4. Color: White.
   5. Manufacturers: Childers Brand #CP-10/CP-11, Eagle Bridges - Marathon Industries #550, Foster Brand #46-50, Mon-Eco Industries, Inc. #55-50, Vimasco Corporation #WC-1/WC-5 or equal.

2.7 LAGGING ADHESIVES

A. Adhesives shall be compatible with insulation materials, jackets, and substrates.
   1. Comply with MIL-A-3316C, Class I, Grade.
   2. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
   4. Service Temperature Range: 0 to 180°F (-18 to 82°C).
   5. Color: White.
   6. Manufacturers: Childers Brand #CP-50 AHV2, Foster Brand #30-36, Vimasco Corporation #713/714 or equal.

2.8 SEALANTS

A. Joint Sealants:
   1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate.
      a. Manufacturers: Childers Brand #CP-76, Marathon Industries#405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05, Pittsburgh Corning Corporation #Pittseal 444 or equal.

2. Joint Sealants for Polystyrene.
   a. Manufacturers: Childers Brand #CP-70, Marathon Industries #405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05 or equal.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: -100 to 300°F (-73 to 149°C).
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Shall be compliant with requirements of LEED IEQ Low-Emitting Materials.

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76, Eagle Bridges - Marathon Industries #405, Foster Brand #95-44, Mon-Eco Industries, Inc. #44-05 or equal.

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76 or equal.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
7. Manufacturers: ABI, Ideal Tape Division #428 AWF ASJ, Avery Dennison Corporation #Fasson 0836, Compac Corporation #105, 3M Venture Tape #1540 CW Plus/1542 CW Plus/1542 CW Plus/SQ or equal.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
7. Manufacturers: ABI Tape #491 AWF FSK, Avery Dennison Corporation #Fasson 0827, Compac Corporation #110 and 111, 3M Venture Tape #1525 CW NT/1528 CW/1528 CW/SQ or equal.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches (50 mm).
   2. Thickness: 6 mils (0.15 mm).
   3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
   6. Manufacturers: ABI Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS or equal.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
   6. Manufacturers: ABI Tape #488 AWF, Avery Dennison Corporation #Fasson 0800, Compac Corporation #120, 3M Venture Tape #3520 CW or equal.

2.10 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
   2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
   3. Manufacturers: ITW Insulation Systems, Gerrard Strapping and Seals, RPR Products, Inc., Insul-Mate Strapping, Seals, and Springs or equal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
      a. Manufacturers: AGM Industries #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
      a. Manufacturers: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
      a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
      b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
      c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

d. Manufacturers: AGM Industries, Inc. #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners, Inc.#Spindle or equal.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   d. Manufacturers: GEMCO #Nylon Hangers, Midwest Fasteners, Inc.#Nylon Insulation Hangers or equal.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12 gauge, 0.106-inch - (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.
   d. Manufacturers: AGM Industries, Inc. #Tactoo Self-Adhering Insul-Hangers, GEMCO #Peel & Press, Midwest Fasteners #Self Stick or equal.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless-steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
   b. Manufacturers: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Manufacturers: GEMCO, Midwest Fasteners, Inc or equal.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.
   1. Manufacturers: C & F Wire or equal.

2.11 ACOUSTICAL PIPE WRAP

A. Acoustical pipe lagging for noisy pipes. Barrier material shall meet the sound transmission loss and physical properties performance requirements as follows:
   1. Vinyl noise barrier with reinforced foil facing on one side.
   2. Service Temperature Range: -40°F to 220°F (-40°C to 104°C).
   3. Nominal density: 2 lbs./sf or greater.
   4. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤450 ratings as tested per ASTM E84. Not compliant for use in return air plenums without metal jacket.

5. Sound transmission class: 31
6. Sound Transmission Loss (dB) Table per ASTM E90:

dB Reduction at each Octave Band Center Frequency (Hz)						
125 hz	250 hz	500 hz	1000 hz	2000 hz	4000 hz	STC
16	22	26	32	35	40	31

7. Manufacturers: Sound Seal #B-20 LAG/QFA-9, Kinetics #KNM-100AL Series or equal.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that piping has been tested for leakage in accordance with specifications before applying insulation materials. All piping and ductwork shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.2 INSTALLATION

A. General:
   1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
   2. Remove and replace any insulation that has become wet or damaged during the construction process.
   3. Pipe fittings, valves, pipe flanges, pumps, strainers, gauge fittings, etc., shall be insulated to the same insulation thickness as adjoining piping and as required by local energy code.

B. Piping Insulation:
   1. Locate insulation and cover seams in least visible locations unless otherwise specified.
   2. Neatly finish insulation at supports, protrusions, and interruptions.
   3. Provide vapor retardant jackets with self-sealing laps on insulated cold pipes conveying fluids below ambient temperature. Insulate complete system. Staples used on pipes conveying fluids below ambient temperatures (cold systems) must be covered with approved mastic.
   4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self-sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
   5. Provide insert between support shield and piping on piping 1-1/2” diameter and larger. Fabricate insert using hydrous calcium silicate or other heavy density insulating material suitable for temperature and required insulation thickness. Insulation inserts shall not be less than the following lengths:
      a. 1-1/2" to 2-1/2" pipe size: 10" long
      b. 3" to 6" pipe size: 12" long
      c. 8" to 10" pipe size: 16" long
      d. 12" and over: 22" long
   6. Use of metal saddles is acceptable as specified in Section 230500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
   7. Use of pipe hangers designed as an insulation coupling is acceptable in lieu of saddles and other devices.
   8. For insulated pipe exposed in mechanical equipment rooms or in finished spaces below seven (7) feet above finished floor, cover insulation with PVC or metal jacketing.

9. Where pumps, valves (manual and control types), strainers, etc., with insulation require periodic opening for maintenance, repair or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
    a. Cold Systems: Provide elastomeric foam for pumps and strainers.
    b. Hot Systems: Provide removable blanket covers on valves, pumps, and strainers.
10. For exterior applications:
    a. Apply weather-resistant protective finish to flexible elastomeric insulation. Insulation seams shall be located on the bottom side of horizontal piping.
    b. All lateral and longitudinal insulation joints to be sealed with low VOC, UV inhibitive adhesive.
    c. Provide weather protection jacket over insulation. Insulated pipe lengths, pumps, fittings, joints, and valves shall be covered with aluminum jacket or stainless steel jacket. PVC or plastic jackets are not allowed exterior to the building. Jacket seams shall be located on bottom side of horizontal piping. All lateral jacket joints shall be caulked with a minimum 20-year silicone sealant (clear). All longitudinal jacket joints, except those at the bottom of a horizontal pipe run, shall be caulked with a minimum 20-year silicone sealant (clear).
11. For underground installations, install per manufacturer's written instructions and recommendations.
12. When maintenance or service access for equipment will result in foot traffic over floor mounted insulated piping the contractor is to fabricate a permanent removable walkway to prevent damage to the piping and insulation.
13. Special Application Requirements for Chilled Water Systems:
    a. Non-factory vapor retarded piping and fittings: Spiral wrap insulation with vapor retarder tape. Cover with PVC jacket.
    b. 90/45/tee fittings: Provide material routed out of bun stock to the shape of the elbow, cut in half and applied to the fitting and spiral wrapped with vapor retarder tape. Cover with PVC fitting cover.
    c. Installation shall conform to insulation manufacturer’s installation guide.
    d. Longitudinal jacket laps for pipe insulation installed on piping systems with operating temperatures below ambient shall be vapor sealed with factory-applied pressure-sensitive adhesive vapor retarder, self-sealing lap. For proper sealing, firmly rub lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool. Vapor seal all circumferential joints with factory-furnished, matching pressure-sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool. Additionally, coat raw edges of pipe insulation sections with vapor retarder mastic at 12 foot to 21 foot intervals; at Engineer's discretion on straight piping, and on either side of all fittings, flanges or valves. Vapor retarder mastic shall completely coat the ends of the pipe and extend onto the bore of the pipe insulation and onto the jacketing a minimum of 2 inches.
    e. Where pipe attachments or seismic supports are bolted or welded directly to the pipe provide insulation and vapor barrier around such metal support elements, that extend beyond the pipe insulation, as required to prevent condensation from forming on exposed metal and bolts.

14. Jacket Locations for Pipe, Valve and Fittings. Provide protective insulation jackets for the following locations where not defined elsewhere in the specifications for piping systems:

Insulation Jacket Location	Jacket Material
Indoors: Concealed in Accessible Ceiling Voids.	None.
Indoors: Concealed in Inaccessible Ceiling Voids.	None.
Indoors: Concealed in Accessible Portions of Shafts or Chaseways.	None.
Indoors: Concealed in Inaccessible Portions of Shafts or Chaseways.	None.
Indoors: Mechanical Rooms.	PVC or Aluminum or Stainless Steel to seven (7) feet AFF.
Indoors: Exposed to view in normally occupied spaces such offices, conference rooms, restaurants and retail spaces.	PVC.
Indoors: Exposed to view in warehouse, storage and manufacturing spaces.	None.
Outdoors: Exposed to weather.	Aluminum or stainless steel with white coating for low emissivity.
Outdoors: Exposed in covered outdoor areas such as garages or under canopies.	Aluminum or stainless steel.
Outdoors: Located in vaults or accessible concrete trenches.	Aluminum or stainless steel.

3.3 PIPING INSULATION SCHEDULE

A. TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED.

1. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Increase thickness by 1/2" (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior "K" factors. Refer to "PART 2-PRODUCTS" for characteristics of each insulation material listed below.

PIPE INSULATION INDEX	
INSULATION KEY CODE	INSULATION TYPE
PI-A	Preformed Flexible Mineral Wool or Fiberglass.
PI-B	Preformed Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene.
PI-C	Preformed Rigid Closed-Cell Phenolic Foam.
PI-D	Preformed Rigid Closed-Cell Polyisocyanurate Foam. Limited to non-plenum rated applications.
PI-E	Rigid Preformed Hydrous Calcium Silicate.
PI-F	Rigid Closed-Cell Cellular Glass.
PI-G	Flexible Low Temperature Aerogel.
PI-H	Flexible High Temperature Aerogel.
PI-I	Flexible Extreme High Temperature Aerogel.

TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Insulated pipes at pipe hangers and supports with saddles or 360° shields.	**PI-E**	Thickness as required by State Energy Code. See Table 2 below. Refer to 230500 Basic HVAC Materials and Methods for length of saddles and shields based on pipe size. Required on pipe sizes 1-1/2" and larger.
Exterior condenser water supply and return systems and fittings in freezing climates.	**PI-A, B, C, D, E**	Exterior installation where exposed to freezing conditions provide 1" thickness all pipe sizes.
Exterior condenser water supply pipes and fittings where buried.	**PI-A, B, C, D, E**	Where supply is buried and/or total supply distance is greater than 100 feet from mechanical compressors. Provide 1" thickness all pipe sizes.
Interior condenser water supply and return systems and fittings (60□F-105□F).	**N/A**	Not required.
Cooling coil condensate drain piping and traps located inside spaces within the building, and above ceilings and in attics.	**PI-A or B**	Provide 1/2" (minimum) thickness insulation, all pipe sizes. Refer to Division 22.
Cooling coil condensate drain piping and traps located inside the building, in mechanical rooms located in buildings located in humid climates defined as "A-Moist" or "C-Marine" in the IECC.	**PI-A or B**	Provide 1/2" (minimum) thickness insulation, all pipe sizes. Refer to Division 22.
Cooling coil condensate drain piping and traps located outdoors.	**N/A**	Not required.
Refrigerant suction piping.	**PI-B**	Provide 3/4" (minimum) thickness insulation or increased thickness as required by State Energy Code. See Table 2 below.
Refrigerant liquid and hot-gas piping.	**PI-B**	Provide 3/4" (minimum) insulation for all warm/hot piping in close proximity to human contact and where located in enclosed ceiling, shaft or chase spaces.
Refrigerant piping for heat pump and VRF systems.	**PI-B**	Provide 3/4" (minimum) thickness insulation on all piping.
Steam safety valve vent piping systems.	**PI-A, D, F, H**	Provide 1" insulation thickness, all piping sizes. Provide aluminum jacket on exterior insulated piping.

B. TABLE 2: MINIMUM PIPING INSULATION THICKNESS BASED ON FLUID TEMPERATURE AND PIPING SIZE.

1. California

Table 2 Insulation Based on California T-24 Energy Code Table 120.3-A Minimum Pipe Insulation Thicknesses or Greater							
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)				
			Less than 1	1 and 1-1/4	1-1/2 to 3	4 to 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water) and Domestic Services Water Heating Systems							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.31	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.22-0.28	100	1.0	1.5	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
40-60 residential	0.21-0.27	75	0.75 for residential		1.0	1.0	1.0
Below 40	0.20-0.27	75	1.0	1.5	1.5	1.5	1.5

2. Oregon

Table 2 Insulation Based on Oregon OEESC Energy Code Table 503.2.8 Minimum Pipe Insulation Thicknesses or Greater							
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)				
			Less than 1	1 and 1-1/4	1-1/2 to 3	4 to 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water)							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
Below 40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.5

3. Washington

Table 2 Insulation Based on Washington WSEC Energy Code Table C403.2.9 Minimum Pipe Insulation Thicknesses or Greater							
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)				
			Less than 1	1 and 1-1/4	1-1/2 to 3	4 to 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water)							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.31	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
Below 40	0.20-0.26	75	0.5	1.0	1.0	1.0	1.5

4. International Energy Conservation Code

Table 2 Insulation Based on International Energy Conservation Code Table C403.11.3 Minimum Pipe Insulation Thicknesses or Greater							
FLUID TEMPERATURE RANGE (°F)	CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)	INSULATION MEAN RATING TEMPERATURE (°F)	NOMINAL PIPE DIAMETER (in inches)				
			Less than 1	1 to 1-1/2	2 to 3	4 to 6	8 and larger
			INSULATION THICKNESS REQUIRED (in inches)				
Space heating systems (steam, steam condensate and hot water)							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.22-0.28	100	1.0	1.5	1.5	1.5	1.5
Space cooling systems (chilled water, refrigerant and brine)							
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
Below 40	0.20-0.26	75	0.5	1.0	1.0	1.0	1.5

3.4 ACOUSTIC PIPE WRAP

A. Acoustic pipe wrap is to be used in piping system which occur over occupied spaces for the following:
   1. Horizontal condenser water riser offsets.
   2. Pipe, valves and fittings where water velocity exceeds 8 feet per second.

END OF SECTION 230719

SECTION 230900

BUILDING AUTOMATION SYSTEM (BAS) CONTROLS

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include but not necessarily be limited to the following:
   1. Provide new direct digital Building Automation System (BAS) for the new building with all hardware, software, controller, devices, sensors, conduit, wiring, and labor as required to provide complete and operational systems.
   2. Provide Tridium front end to interface existing building BAS systems with new building BAS.

B. General Requirements
   1. The work includes designing, providing and installing a complete and fully operable building automation system as described in this Section of the Specification and as shown on the contract construction drawings and shall be in accordance with rules, regulations and standards as required by the authorities having jurisdiction. Any alternations to the quantity or location of the control panels shall be coordinated with the Electrical Contractor and General Contractor prior to bidding. Any BAS changes after bidding must be coordinated with Electrical Contractor and General Contractor at no additional cost to Owner.
   2. Submit shop drawings of the entire control system components fully coordinated with major equipment suppliers' requirements. Provide proposed programming logic sequences of control functions on each system.
   3. Installation of control components other than valves, dampers and sensing wells as required for a complete and workable system.
   4. This Contractor shall furnish, install and coordinate the interlock and control wiring as specified and/or required for a complete and workable control system.
   5. Controls dampers are specified and furnished in Section 233113 of these specifications. Provide damper actuators, wiring and conduit as required to operate all dampers as shown.
   6. Upon completion of the installation, data entry and programming, provide complete validation and adjustment of specified control system through period of testing and Owner’s acceptance. The control contractor shall perform a point-to-point check out of all newly installed points to verify point existence, proper end to end connection and correct SI units with the Owners Representative.
   7. The entire program and sequence of operation with the final points list shall be verified by the Control Contractor, the Owner’s Representative, and signed by both parties. A copy of the final program, sequence of operation, and points list shall be submitted to the Engineer for approval and inclusion with the operation and maintenance manuals.
   8. Owner training on operation of the control system.
   9. One-year warranty on workmanship and materials.
   10. Interlocking of electrical systems and motors as shown on Drawings, except where specifically shown on electrical drawings.

1.2 RELATED WORK IN OTHER SECTIONS

A. Refer to Division 0 and Division 1 for related contractual requirements.

B. Provide certificates of calibration for all sensors required for control and monitoring including temperature and pressure.

C. Refer to Division 23 and the following sections for Mechanical or Electrical Provision.
   1. Division 01 - Submittal Procedures
   2. Division 01 - Commissioning

3. Section 230500: Basic HVAC Materials and Methods
4. Section 230593: Testing, Adjusting, and Balancing
6. Section 230902: Variable Frequency Drives
7. Section 232113: Hydronic Piping, Valves and Specialties
8. Section 233113: Air Distribution

20. Sections 237000 through 238999 equipment
21. Division 26 – Electrical Materials and Methods
22. Division 28 – Electronic Safety and Security

D. Refer to Division 26 sections for Electrical Provisions. Sources of 120-volt electrical power as indicated on the electrical drawings and specifications for control system components furnished by this section. The controls contractor shall be responsible for all additional electrical distribution from these connection points to the control panels and other controls devices.

E. BAS contractor will furnish, but not install the following:
1. Air flow measuring stations: furnish to mechanical installer and coordinate per manufacturer's requirements.
2. Flow meters: furnish to mechanical installer and coordinate per manufacturer's requirements.
3. Flow switches: furnish to mechanical installer and coordinate per manufacturer's requirements.
4. Hydronic pressure and temperature sensor wells: furnish to mechanical installer and coordinate per manufacturer's requirements.
5. Control valves: furnish to mechanical installer and coordinate per manufacturer's requirements.

1.3 REFERENCE STANDARDS

A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
2. ANSI/ASHRAE Standard 135-2012, BACnet.
3. International Building Code (IBC), including local State and Local amendments.
4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
5. National Electrical Code (NEC).
6. FCC Part 15, Subpart J, Class A.
7. EMC Directive 89/336/EEC (European CE Mark).
8. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences.

B. City, county, state, and federal regulations and codes in effect as of contract date.

C. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.

1.4 GENERAL REQUIREMENTS

A. Furnish a distributed logic BACnet-based control system including operator's workstation. The operator's workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2012, BACnet. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance

Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

B. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.

C. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.

D. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

E. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

F. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

G. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

H. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

I. Provide a comprehensive operator and technician training program as described herein.

J. Provide as-built documentation, operator's terminal software, a software key for a minimum of one additional computer (coordinate with Owner's Representative if additional keys are required), diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

K. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

1.5 SYSTEM DESCRIPTION

A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2012, BACnet and achieved listing under the BACnet Testing Laboratories BACnet - Advanced Workstation Software (B-AWS). This system is to control all mechanical equipment, including all unitary equipment such as fan-coils, air handlers and any other listed equipment using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

B. The Building Automation System (BAS) application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, and a full suite of field engineering tools including graphical programming and applications.

C. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

D. All application controllers for every piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller through BACnet LAN.

E. Room sensors shall be provided with digital readout that allow the user to view room temperature, CO2 or relative humidity, adjust the room setpoint within preset limits and set desired override time. User shall also be able to start and stop unit from the digital sensor. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow a technician to balance VAV zones and access any parameter in zone controller directly from the room sensor. Field service mode shall have the ability to be locked out.

1.6 QUALITY ASSURANCE

A. The BAS shall be designed, installed, commissioned, and serviced by contractor authorized and trained personnel. System provider shall have an in-place support facility within two (2) hours response time of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.

B. The manufacturer and installer shall have a minimum of 5 years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. A list of successful past projects of similar type, size and complexity shall be submitted. In addition, a reference list of names, addresses and telephone numbers of the design Engineer and the Owner's Representative for each installation shall be provided. The references may be contacted and questioned about the timely delivery, installation, operation and service received for each installation.

C. The contractor shall provide experienced project manager for this work, responsible for direct supervision of the design, installation, start-up and commissioning of the BAS system.

D. The Bidder shall be regularly engaged in the design, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. Bidders shall provide a list of at least 10 projects, similar in size and scope to this project completed within the past 3 years.

E. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.

F. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

H. Control system shall be engineered, programmed and supported completely by representative's local office that must be within 100 miles of project site.

I. Control components shall be products of the same manufacturer only, unless indicated otherwise and approved by Owner's Representative. Example – all valves shall by one manufacturer and all temperature sensors shall be by one manufacturer.

1.7 SUBMITTALS

A. Drawings
   1. The system supplier shall submit point-to-point engineered drawings, control sequence, and bill of materials for approval.
   2. Drawings shall be submitted in a standard size of 11" x 17" (ANSI B), or larger.
   3. Eight complete sets (copies) of submittal drawings shall be provided.

4. Drawings shall be available on portable memory device, DVD or CD disk media.

B. System Documentation
1. Include the following in submittal package:
a. System configuration diagrams in simplified block format.
b. All input/output object listings and an alarm point summary listing.
c. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
d. Complete bill of materials, valve schedule with Cv, valve pressure drop at design flow, and damper schedule.
e. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
f. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
g. For all system elements—operator’s workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2012.
h. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
i. A list of all functions available and a sample of function block programming that shall be part of delivered system.

C. Project Management
1. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Warrant work as follows:
1. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Warrant all actuators for a period of five (5) years.
3. Respond during normal business hours within 24 hours of Owner’s warranty service request.
4. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
5. If Owner’s Representative determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Owner’s Representative will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
6. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner’s written authorization.
7. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable BAS Manufacturers include:
1. ALC
2. Alerton
3. Andover
4. Delta
5. Distech
6. Honeywell
7. Johnson Controls
8. Reliable Controls
9. Schneider Electric
10. Siemens
11. Trane

2.2 OPERATOR'S WORKSTATION

A. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system database. Clients shall access server for all archived data. Each client shall include flexibility to access graphics from server or local drive. Server shall support a minimum of 50 simultaneous clients.

B. Primary Operator Workstation Hardware
1. All workstations shall be general purpose microcomputer systems serving as an operator station in a cooperative processing server/client relationship with other connected work stations. The workstation shall consist of a high-speed central processing unit (CPU) with data storage facilities, high-resolution, 24", LCD monitor. Components shall be capable of operating in environments of 60°F to 105°F and relative humidity of 30% to 90%.
2. CPU: Intel Xeon CPU E5-2640 x64, or better, and compatible with dual & quad core processors.
3. Memory: 8 GB (minimum).
4. Hard Drive: 1 TB (minimum) for the BAS operating software.
5. Hard Drive: 4 TB (minimum) to be used for trend log archiving of annual data.
6. Display: Video card and monitor capable of displaying 1920x1080 pixel resolution or better.
7. Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector, or greater).
8. Keyboard: The keyboards shall be the enhanced with 101 keys and quiet.

C. Displays
1. In general, the operator's workstation shall display all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's workstation shall display all data using three-dimensional graphic representations of all mechanical equipment.
2. A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label pushbuttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A security level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.
3. The BAS displays shall have the ability to link to content outside of the BAS system. Such content shall include but is not limited to: Launching external files in their native applications (for example, a Microsoft Word document) and launching a Web browser resolving to a specified Web address.

4. The BAS system shall have the ability to run multiple, concurrent displays windows showing continuously updated data.

D. Password Protection
1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's assigned functions when user is logged on. This includes displays as outlined above.
2. Each operator's terminal shall provide security for a minimum of 200 users. Each user shall have an individual User ID, User Name, and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be capable of accepting 8 characters or more, User Name shall be 0–29 characters, and Passwords must accept a minimum of 4 characters and be capable of accepting 8 characters or more.
3. System shall include an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.
4. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.

E. Operator Activity Log
1. Operator Activity Log that tracks all operator changes and activities shall be included with system. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation. Operator shall be able to print the Operator Activity log display.
2. Log shall be gathered and archived to hard drive on operator's workstation as needed. Operator shall be able to export data for display and sorting in a spreadsheet.

F. Scheduling
1. Operator's workstation shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily, with events being the highest.
2. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.
3. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
4. Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Each and every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied setpoint is to be attained. Optimum start feature shall calculate the startup time needed to match zone temperature to setpoint. User shall be able to set a limit for the maximum startup time allowed.

G. Alarm Indication and Handling.
1. Operator's workstation shall provide audible, visual, printed, email or test means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) currently running. Printout of alarms shall be sent to the assigned terminal and port. Alarm notification can be filtered based on the User ID's authorization level.
2. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and

date of object state return to normal, time and date of alarm acknowledgment, and identification of operator acknowledging alarm.

3. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the operator's terminal, client or through remote communication using email (Authenticated SMTP supported).

H. Trendlog Information

1. System server shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. Samples may be viewed at the operator's workstation. Operator shall be able to view all trended records, both stored and archived. All trend log records shall be displayed in standard engineering units. Annual trend log data shall be archived by year for future analysis.
2. Software that is capable of graphing the trend logged object data shall be included. Software shall be capable of creating two-axis (X, Y) graphs that display up to 10 object types at the same time in different colors. Graphs shall show object values relative to time. Each trend log shall support a custom scale setting for the graph view that is to be stored continuously.
3. Operator shall be able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.
4. System shall be capable of using Microsoft SQL as the system database.

I. Energy Log Information

1. System server shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.
2. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.
3. Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.
4. System shall display archived data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.

J. Demand Limiting

1. System shall include demand limiting program that includes two types of load shedding. One type of load shedding shall shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding shall adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.
2. Binary shedding shall include minimum of five (5) priority levels of equipment shedding. All loads in a given priority level shall be shed before any loads in a higher priority level are shed. Load shedding within a given priority level shall include two methods. In one, the loads shall be shed/restored in a "first off-first on" mode, and in the other the loads are just shed/restored in a "first off-last on" (linear) fashion.

3. Analog shed program shall generate a ramp that is independently used by each individual zone or individual control algorithm to raise the appropriate cooling setting and lower appropriate heating setting to reduce energy usage.
4. Status of each and every load shed program shall be capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program shall be displayed along with English description of each load.

K. Tenant Activity
1. System shall include program that monitors after-hours overrides by tenants, logs that data, and generates a bill based on usage and rate charged for each tenant space. Tenant Activity program shall be able to assign multiple zones, from a list of every zone connected to system, to a particular tenant. Every zone is monitored for after-hour override usage and that data logged in server. Operator may then generate a bill based on the usage for each tenant and the rate charged for any overtime use.
2. Configuration shall include entry of the following information for use in logging and billing:
   a. Tenant's contact name and address.
   b. One or multiple tenant zones that make up a total tenant space, including a separate billing rate for each separate zone.
   c. Minimum and maximum values an event duration and event limit.
   d. Property management information.
   e. Overall billing rate.
   f. Seasonal adjustments or surcharge to billing rate.
   g. Billing notification type such including, but not limited to printer, file and email.
   h. Billing form template.
   i. Logging shall include recording the following information for each and every tenant event.
   j. Zone description.
   k. Time the event begins.
   l. Total override time.
   m. Limits shall be applied to override time.
3. A tenant bill shall be generated for a specific period using all the entered configuration data and the logged data. User with appropriate security level shall be able to view and override billing information. User shall be able to select a billing period to view and be able to delete events from billing and edit a selected tenant activity event's override time.

L. Reports
1. System server shall be capable of periodically producing reports of trend logs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

M. Configuration/Setup
1. Provide means for operator to display and change system configuration. This shall include, but not be limited to, system time, day of the week, date of daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.

N. Field Engineering Tools
1. Operator's workstation software shall include field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. User shall be able to select a graphical function block

from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.

2. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
3. System shall automatically notify the user when a device that is not in the database is added to the network.
4. System shall include backup/restore function that will back up entire system to selected medium and then restore system from that media. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.
5. The system shall provide a means to scan, detect, interrogate, and edit third-party BACnet devices and BACnet objects within those devices.

O. Workstation Hardware
1. Workstation/server computer minimum requirements
a. Enterprise Server (supports heavy trending and/or alarm handling at very large sites using SQL Server)
b. 64-bit Windows 8.1 Enterprise, Windows Server 2012 Standard, 2012 R2 Standard, or better,
c. Browser/client requirements: Most current versions of the following: Internet Explorer, Firefox, Chrome, Safari (Mac OS X).

P. Software
1. At the conclusion of project, contractor shall provide to the Owner's Representative a portable memory device or DVD ROM that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the Owner to completely restore the system in the case of a computer malfunction.

2.3 WEB INTERFACE

A. General
1. BAS supplier shall provide Web-based access to the system as part of standard installation. User must be able to access all displays of real-time data that are part of the BAS using a standard Web browser. Web browser shall tie into the network through Owner-supplied Ethernet network connection. Web page host may be a separate device that resides on the BAS BACnet network, but is not the BAS server for the control system. BAS server may be a separate computer from the Web page host device. The Web page software shall not require a per-user licensing fee or annual fees. The Web page host must be able to support simultaneous users with the ability to expand the system to accommodate an unlimited number of users.

B. Browser Technology
1. No special vendor-supplied software shall be needed on computers running browser. All displays shall be viewable and the webpage host shall directly access real-time data from the BAS BACnet network. Data shall be displayed in real-time and update automatically without user interaction. User shall be able to change data on displays if logged in with the appropriate user name and password.

C. Communications
1. Web page host shall support Ethernet network connections. A network connection shall be used to gather real-time data from all the BACnet devices that form the BAS. This network shall communicate using BACnet, allowing the Web page host to gather data directly from units on the local LAN or from other projects connected over a WAN. This network shall also provide the connection to the BAS server for Web page generation.

2. An Ethernet connection shall provide the physical connection to the Internet or an IP-based WAN. It shall be the port that is used for the browser to receive Web pages and data from the Web page host. The Web page host shall act as a physical barrier between the BAS network and the WAN or Internet connection that allows the browser to receive Web pages and data. The two separate network connections provide for a physical barrier to prevent raw BACnet traffic being exposed on the IP network.
3. The Web page host shall provide for complete isolation of the IP and BACnet networks by not routing networking packets between the two networks.

D. Display of Data
1. Web page graphics shown on browser shall be replicas of the BAS displays. User shall need no additional training to understand information presented on Web pages when compared to what is shown on BAS displays. Web page displays shall include animation just as BAS displays. Fans shall turn, pilot lights shall blink, coils shall change colors, and so on.
2. Real-time data shall be shown on all browser Web pages. This data must be directly gathered using the BACnet network and automatically updated on browser Web page displays without any user action. Data on the browser shall automatically refresh as changes are detected without re-drawing the complete display.
3. It shall be possible for user from browser Web page to change data if the user is logged on with the appropriate password. Clicking on a button or typing in a new value shall change digital data. Using pull-down menus or typing in a new value shall change analog data.
4. Data displays shall be navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

E. Time Schedule Adjustment
1. Web access shall allow user to view and edit all schedules in the system. This includes three types of schedules: standard, holiday and event. Display of schedules shall show interaction of all schedules on a single display so user sees an overview of how all work together. User shall be able to edit schedules from this display.
2. Display of all three schedule types must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.
3. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

F. Logging of Information
1. User shall use standard browser technology to view all trendlogs in system. User shall be able to view logged data in tabular form or graphical format. User shall be able to adjust time interval of logged data viewed and shall be able to adjust Y axis of data viewed in graphical format. User shall also be able to download data through the Web interface to local computer. Data shall be in CSV format.

G. Alarm Handling
1. Web interface shall display alarms as they occur. User shall be able to acknowledge alarms using browser technology. In addition, user shall be able to view history of alarm occurrence over a user-selected time frame. In addition, those alarms may be filtered for viewing per user-selected options. A single selection shall display all alarms that have not been acknowledged.

H. Web Page Generation

1. Web pages shall be automatically generated from the BAS displays that reside on the BAS server. User shall access Web page host through the network and shall initiate a Web page generation utility that automatically takes the BAS displays and turns them into Web pages. The Web pages generated are automatically installed on the Web page host for access using any computer's standard browser. Any system that requires use of an HTML editor for generation of Web pages shall not be considered.

I. Password Security and Activity Log
1. Access through Web browser shall utilize the same hierarchical security scheme as BAS system. User shall be asked to log on once the browser makes connection to Web page host. Once the user logs in, any and all changes that are made shall be tracked by the BAS system. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have logged in to the system, regardless of whether those changes were made using a browser or through the BAS workstation.

J. BACnet Communication
1. Web server shall directly communicate to all devices on the BAS network using BACnet protocol. No intermediate devices shall be necessary for BACnet communication.

2.4 BUILDING NETWORK CONTROLLER

A. Building Network Controller
1. BACnet Conformance
a. Building Network Controller shall be approved by the BACnet Testing Laboratories as meeting the BACnet Building Controller requirements.

B. Building network controller modules shall provide normal 7-day scheduling, holiday scheduling and event scheduling.
1. Logging Capabilities
a. Logs shall be supported in the building network controller. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
b. Logs may be viewed both on-site or off-site using WAN or remote communication.
c. Building network controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.
d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
2. Alarm Generation
a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
b. Each alarm may be dialed out as noted elsewhere.
c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
d. Controller must be store alarms as BACnet event enrollment objects, with system destination and actions individually configurable.
3. Demand Limiting
a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 200 loads using a minimum of two types of shed programs.
b. Load shedding programs in building controller modules shall operate as coordinated with local utility.
4. Tenant Activity Logging
a. Tenant activity logging shall be supported by building network controller module.

C. Ethernet – MS/TP Module
   1. Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
   2. All communication with operator's workstation and all application controllers shall be through BACnet. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz) and MS/TP LAN. Ethernet – MS/TP module shall also route messages from all other building controller modules onto the BACnet Ethernet network.
      a. MS/TP LAN must be software-configurable from 9.6 to 76.8Kbps.
      b. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).

D. MS/TP Module
   1. MS/TP module shall support every listed function in this specification and the following.
   2. Building controller MS/TP module communications shall be though BACnet MS/TP LAN to all advanced application and application-specific controllers. MS/TP module shall also route messages to Ethernet – MS/TP module for communication over WAN.
      a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.
      b. Configuration shall be through RS-232 connection.

E. Power Supply Module
   1. Input for power shall accept between 17–30VAC, 47–65Hz.
   2. Power supply module shall include rechargeable battery for orderly shutdown of controller modules including storage of all data in flash memory and for continuous operation of real-time clocks for minimum of 20 days.

F. Modbus Module
   1. Modbus Module shall support every function as listed in this specification.
   2. Building Controller Modbus module communications shall be via one of three types of ports: EIA-485, EIA-422 or RS-232 connection. Modbus module shall convert Modbus data into BACnet objects. Modbus module shall also route messages to Ethernet-MS/TP module for BACnet Ethernet communication over WAN.
      a. Modbus Module shall support ASCII or RTU Modbus communication at 9600 or 4800 baud.
      b. EIA-422 and EIA-232 connection shall support one connection of Modbus unit.
      c. EIA-485 connection shall support connection of up to 247 Modbus units.
      d. Configuration shall be via RS-232 connection.
   3. BACnet Translation
      a. All Modbus data shall be translated into BACnet objects by the Modbus module. All configuration tools shall be supplied to assure data is translated as necessary to the correct format and value.
      b. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

2.5 APPLICATION CONTROLLERS – GENERAL

A. All application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

B. All program sequences shall be stored on board controller in memory. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller ten (10) times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

C. Provide all application controllers with a minimum of 10% spare points for analog input, analog output, digital input and digital output signals.

2.6 APPLICATION CONTROLLERS –AIR HANDLER OR CENTRAL PLANT

A. Provide one or more native BACnet application controllers to adequately cover all objects listed in object list. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

B. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.

C. Application controller shall include support for intelligent room sensor. Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

D. Schedules
   1. The controller shall support a minimum of three (3) BACnet Schedule Objects and have a real-time clock on board with battery backup to maintain time through a power loss.

E. Logging Capabilities
   1. Controller shall support a minimum of 50 trend logs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
   2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in (MS Jet Database or SQL) database form and shall be available for use in third-party spreadsheet or database programs.

F. Alarm Generation
   1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
   2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
   3. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

G. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

2.7 APPLICATION CONTROLLER – UNITARY MECHANICAL EQUIPMENT

A. Provide one native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

2.8 AUXILIARY CONTROL DEVICES

A. Temperature Sensors (TS)
   1. Duct air temperature (duct mounted, indoor location)
      a. Thermistor type with 1/4" stainless steel probe and junction box. 10K ohm, type II, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe length as required to extend 25% (minimum) to 50% (maximum) into the width of duct. Manufacturer: Veris #TF Series, Dwyer Instruments #TE-DFG Series, Kele (Minco) #TT Series, or equal.
   2. Duct air temperature (duct mounted, outdoor location)
      a. Thermistor type with 1/4" stainless steel probe and weather-tight junction box. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe length as required to extend 25% (minimum) to 50% (maximum) into the width of duct. Manufacturer: Veris #TG Series, Dwyer Instruments #TE-DFW Series, Kele (Minco) #TT Series, or equal.
   3. Outside air temperature (wall mounted location)
      a. Thermistor type with stainless steel or platinum probe and weather-proof aluminum junction box. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe encased in durable radiation shield with radiation solar shield. Manufacturer: Veris #TO Series, Dwyer Instruments #TE Series, or equal.
   4. Pipe or tank fluid temperature (immersion probe)
      a. Immersion probe type temperature sensor encased in a corrosion-resistant stainless steel thermowell. Thermistor type with metallic housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Manufacturer: Veris #TIG Series, Dwyer Instruments #TE Series, or equal.
   5. Temperature averaging (coil mounting)
      a. Thermistor type with bendable copper tubing element water-resistant junction box. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe length as required to extend across coil face at least twice to cover two corners and one midpoint. Mounting of tubing shall utilize Veris #AA64 mounting clips, or equal. Manufacturer: Veris #TA Series, Kele #ACI Series, or equal.

B. Intelligent Room Temperature Sensor (TS) with LCD Readout
   1. Sensor shall contain a backlit LCD digital display and user function keys along with temperature sensor. Controller shall function as room control unit and allow occupant to raise and lower setpoint, and activate terminal unit for override use-all within limits as programmed by building operator. Sensor shall also allow service technician access to hidden functions as described in sequence of operation.
   2. The intelligent room sensor shall simultaneously display room setpoint, room temperature, outside temperature, and fan status (if applicable) at each controller. This unit shall be programmable, allowing site developers the flexibility to configure the display to match their application. The site developer should be able to program the unit to display time-of-day,

room humidity and outdoor humidity. Unit must have the capability to show temperatures in degrees Fahrenheit or Centigrade.

3. Override time may be set and viewed in half-hour increments. Override time countdown shall be automatic, but may be reset to zero by occupant from the sensor. Time remaining shall be displayed. Display shall show the word “OFF” in unoccupied mode unless a function button is pressed.
4. See sequence of operation for specific operation of LCD displays and function keys in field service mode and in normal occupant mode. Provide intelligent room sensors as specified in point list. Field service mode shall be customizable to fit different applications. If intelligent room sensor is connected to VAV controller, VAV box shall be balanced and all air flow parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.

C. Humidity Sensors
1. Indoor space humidity (wall mounted inside):
   a. 1% accuracy thin film capacitive replaceable sensor element, LED display. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
   b. Manufacturers: Veris #HW Series, Dwyer Instruments #RHP-W Series or equal.
2. Outside air humidity (wall mounted outdoors):
   a. 2% accuracy thin film capacitive replaceable sensor element, with weatherproof housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
   b. Manufacturers: Veris #HO Series, Dwyer Instruments #RHP-W Series, or equal.
3. Duct air humidity (duct mounted indoor application):
   a. Humidity sensor, 2% accuracy thin film capacitive replaceable sensor element, with die cast metal housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
   b. Manufacturers: Veris #HD Series, Dwyer Instruments #RHP-W Series, or equal.
4. Indoor space humidity with temperature (wall mounted inside):
   a. Combination humidity and temperature sensor, 2% accuracy thin film capacitive replaceable sensor element, LED display, push button override and setpoint slider. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
   b. Manufacturers: Veris #HW Series, Dwyer Instruments #RHP-W Series, Vaisala #HMW Series, or equal.
5. Outside air humidity with temperature (wall mounted outside):
   a. Combination humidity and temperature sensor, 2% accuracy thin film capacitive replaceable sensor element, with weatherproof housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
   b. Manufacturers: Veris #HO Series, Dwyer Instruments #RHP Series, Vaisala #HMS Series, or equal.
6. Duct air humidity and temperature (duct mounted indoor application):
   a. Combination humidity and temperature sensor, 2% accuracy thin film capacitive replaceable sensor element, with die cast metal housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
   b. Manufacturers: Veris #HD Series, Dwyer Instruments #RHP Series, Vaisala #HMT Series, or equal.
7. Duct high limit humidity switch (duct mounted indoor application):
   a. Single-stage duct hygrostat with insertion probe to monitor humidity level with NO and NC contacts. Adjustable relative humidity setpoint range of 35 to 100% RH. SPDT 250 Vac/ 15 amp.
   b. Manufacturers: Honeywell #H6045A1002, or equal.

D. CO2 Sensors
1. Indoor space measurement (wall mounted):

a. Non-dispersive infrared sensor in high impact white ABS plastic enclosure. Input power 20 to 30 VDC/24 AC, 100 mA. Analog output 4-20 mA. Operating range 32°F to 122°F (0°C to 50°C). Measurement range of 0-2000 ppm with accuracy of +/- 30 ppm.
b. Manufacturers: Veris #CWE Series, Dwyer #CDT Series, or equal.

2. Outdoor air measurement (indoor duct mounted location):
a. Non-dispersive infrared sensor in high impact white ABS plastic enclosure. Input power 20 to 30 VDC/24 AC, 100 mA. Analog output 4-20 mA. Operating range 32°F to 122°F (0°C to 50°C). Measurement range of 0-2000 ppm with accuracy of +/- 30 ppm.
b. Manufacturers: Veris #CDE Series, Dwyer #CDT Series, or equal.

E. CO2, Humidity, Temperature Combined Sensor (Indoor Wall and Duct Mounted)
1. High impact white ABS plastic enclosure with digital LCD display and adjustable setpoints.
2. Input power 20 to 30 VDC/24 AC, 100 mA.
3. Analog output 4-20 mA.
4. Operating range 32°F to 122°F (0°C to 50°C).
5. CO2 Sensor: Non-dispersive infrared sensor in. Measurement range of 0-5000 ppm with accuracy of +/- 30 ppm.
6. Humidity Sensor: Digitally profiled thin-film capacitive, plus or minus 2% RH. 2% accuracy thin film capacitive replaceable sensor element, with weatherproof housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
7. Temperature Sensor: Thermistor. 2% accuracy thin film capacitive replaceable sensor element.
8. Manufacturers: Veris #CWLP Series or equal.

F. Leak Detector
1. Water leak detector connected to BAS to alarm on detecting the presence of water in the following locations:
a. Secondary condensate drip pan below air conditioning air handling units and fan coils located above spaces with electrical and/or electronic equipment.
b. Below raised access floors with one sensor per 5,000 square feet (maximum) where water pipes are located below access floor. Or, one sensor per 10,000 square feet (maximum) where no water pipes are located below access floor.
c. On the floor adjacent to sump pump(s).
d. On the floor of mechanical rooms adjacent to electrical equipment and/or data/electronics equipment rooms.

2. Features:
a. Mounting: Base mounted.
b. Service: water of conductive fluids.
c. Sensing gap: Minimum 1/8” (3 mm) to maximum 1/4” (6 mm).
d. Switch type: DPDT relay.
e. External power: 1 A @ 24 VAC/DC.
f. Audible alarm: 85 dB @ 1’ distance (0.3 m).
g. Visual indicators:
1) Green to indicate power is supplied.
2) Red to indicate water is detected.
h. Temperature limits: 32 to 122°F (0 to 50°C).
i. Flammability: plenum rated electrical cable with length as required and UL-94 compliant housing.
j. Attached with 1/16” thick double sided adhesive urethane foam tape.

3. Manufacturers: Dwyer #WD3-LP-D2-A, Kele, Veris or equal.

G. Condensate Sensor (Pipe):

1. Solid state condensate detector for locating condensate on chilled water piping. Sensing of water shall provide a signal to the BAS system for control sequence adjustment to raise chilled water temperature.
2. Features:
   a. Service: mounted on metallic pipe from 1/2” to 3” in diameter.
   b. Sensing: 80% to 90% RH (adjustable) surface moisture.
   c. Switch type: SPST open/close.
   d. External power: 40 mA at 24 VAC or 20 mA at 12 to 30 VDC.
   e. Temperature limits: 149°F (65°C).
   f. Flammability: plenum rated electrical cable with length as required and UL-94 compliant housing.
   g. Mounting bracket with stainless steel worm gear clamp for attachment.
3. Manufacturers: Consense #CG-ICM-P or equal.

H. Differential Pressure Transmitters:
1. Duct Static Pressure Transmitter:
   a. Differential pressure transducer with selectable range, +/- 1% accuracy, with push button auto-zero, LCD display.
   b. Manufacturers: Veris #PX Series, Dwyer Instruments #MS2, Kele #DPA Series, or equal.
2. Building Static Pressure Transmitter:
   a. Differential pressure transducer with selectable range, +/- 1% accuracy, with push button auto-zero. Provide with AA05 ceiling mount static pressure pick up, LCD display.
   b. Manufacturers: Veris #PX Series, Dwyer Instruments #MS2, Kele #DPA Series, or equal.
3. Water differential pressure transmitter:
   a. Differential pressure transmitter, wet/wet, switch selectable pressure ranges, jumper selectable port swap, LCD display and NEMA 4 enclosure.
   b. Manufacturers: Veris #PW Series, Dwyer Instruments #MS2, or equal.

I. Differential Pressure Switches:

1. Filter differential pressure switch for status:
   a. Adjustable differential pressure switch, dual scale adjustable knob, silicone diaphragm, single-pole double-throw type, 1/4" tubing diameter, setting range from 0.08 in. w.c. (20 Pa) up to 20 in. w.c. (5000 Pa), and NEMA-3 enclosure.
   b. Manufacturers: Dwyer #ADPS Series or equal.
2. Duct static manual reset high pressure safety switch for supply fan shut down:
   a. Adjustable trip and manual reset, single-pole double-throw, 120-480 VAC. Maximum operating range of -30°F to 180°F (-34°C to 82.2°C) and humidity limit of 80% RH non-condensing. Provide weatherproof housing where mounted outdoors. Adjustable setpoint between 3.0 to 11.75 in. w.c.
   b. Manufacturers: Dwyer #1900-10-MR Series or equal.
3. Duct static manual reset high pressure safety switch for return fan shut down:
   a. Adjustable trip and manual reset, single-pole double-throw, 120-480 VAC. Maximum operating range of -30°F to 180°F (-34°C to 82.2°C) and humidity limit of 80% RH non-condensing. Provide weatherproof housing where mounted outdoors. Adjustable setpoint between 1.40 to 5.5 in. w.c.
   b. Manufacturers: Dwyer #1900-5-MR Series or equal.

J. Air Filter Differential Pressure Gauges: (where not supplied by air handling equipment manufacturer):
1. Dial type, diaphragm-actuated with external zero adjustment and 3-7/8-inch diameter dial.
2. With two (2) static pressure tips, 2-way valves, tubing and mounting plate (and adjustable signal flag).

3. Range as recommended by filter manufacturer.
4. One gauge per filter bank for direct field verification independent of BAS monitoring.
5. Manufacturers: Dwyer 2000 Series Magnehelic or equal.

K. Current Sensors
1. Current sensing switch for fans and pumps:
   a. Current switch with split core, adjustable trip, pilot light, self-gripping split core housing and mounting bracket.
   b. Manufacturers: Dwyer Instruments #CCS Series, Hawkeye #HX08 or equal.
2. Current sensing switch for VFD's:
   a. VFD current switch split core, self-learning adjustable trip, pilot light, self-gripping split core housing and mounting bracket.
   b. Manufacturers: Hawkeye #H614 or equal.
3. Current sensing switch with relay for fan start:
   a. Current switch with split core, integral relay, adjustable trip, pilot light, self-gripping split core housing and mounting bracket.
   b. Manufacturers: Hawkeye, #H900 Series or equal.
4. Current sensing transmitter:
   a. Current sensing transmitter with self-gripping split core, preset slide switches, and removable mounting bracket.
   b. Manufacturers: Hawkeye #H921 or equal.
5. Current sensing transmitter with relay for fan start
   a. Current sensing transmitter with integral relay, slide switches, self-gripping split core, and removable mounting bracket.
   b. Manufacturers: Hawkeye #H931 or equal.

L. Flow Meters – Liquid:
1. Single turbine insertion flow meter:
   a. 316 stainless steel, weather tight aluminum enclosure, and standard or copper installation kit including 1" full port bronze ball valve, close nipple, and branch outlet. Provide with D-100 totalizing display module with BACnet interface.
   b. Manufacturers: Onicon #F-1100 or #F-3000, Impeller (Badger Meter) #SDI Series or equal.
2. Electromagnetic insertion flow meter:
   a. 316 stainless steel, weather tight aluminum enclosure, and standard or copper installation kit including 1" full port bronze ball valve, close nipple and branch outlet. Provide with totalizing display module with BACnet interface.
   b. Manufacturers: Onicon #F-3500, Vortex (Badger Meter) #VN2000, ModMAG (Badger Meter) #M2000 or equal.

M. Flow Meters - Natural Gas:
1. Thermal mass flow meter, in-line or flanged. Provide with totalizing display module with BACnet interface.
2. Manufacturers: Onicon #F-5100 Series, Badger Meter or equal.

N. Flow Meters – Steam:
1. Vortex flow meter, integral 1,000 Ohm platinum RTD for precise temperature measurement, pressure transducer for instantaneous pressure measurement, flow straightener, ANSI class 300 flanges.
2. Manufacturers: Onicon #F-2600 Series, Preso (Badger Meter) #CV Series or equal.

O. BTU Meters:
1. BTU meter with BACnet interface with matched temperature sensors and thermo-wells, NEMA 13 wall mount enclosure, 316 stainless steel, weather tight aluminum enclosure, and standard or copper installation kit including 1" full port bronze ball valve, close nipple, and branch outlet.

2. Manufacturers: Onicon #System-10-BAC and provide with Onicon #F-1100 single turbine insertion flow meter, or Onicon #F-3500 electromagnetic flow meter, or equal by E-Mon D-Mon or Badger.

P. Airflow Measuring Arrays
1. Provide one thermal dispersion airflow/temperature measurement device (ATMD) at each location indicated on the plans, schedules and/or control schematics.
2. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.
3. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.
4. The velocity-weighted average temperature output performance of the ATMD is preferred to that of the specified temperature measuring device (TMD), when the location of the ATMD and TMD are effectively the same.
5. Outside Air Measurement:
   a. Provide a minimum outside airflow measuring station in a straight duct section upstream from the minimum outside air dampers and interfacing control for providing an electronic signal for use by the control contractor in controlling a minimum outside airflow. On outdoor mounted air handling units, outside airflow measurement station is to be factory mounted on the intake side of the outside air intake (upstream of the damper).
6. Sensor Performance:
   a. Fan Installation:
      1) Installed airflow accuracy: +/- 3% to 10% of reading with +/- 0.25% repeatability.
      2) Sensor probe performance: +/- 2% of reading, 0-5000 fpm, +/- 0.15ºF temperature accuracy.
   b. Outside Air/duct Installation:
      1) Installed airflow accuracy: +/- 2% of reading with +/- 0.25% repeatability.
      2) Sensor probe performance: +/- 2% of reading, 0-5000 fpm, +/- 0.15ºF temperature accuracy.
7. Transmitter:
   a. Flow measuring array to include a transmitter for flow and temperature analog output signal for the building energy management system to be user selectable in either 4-20 mA or 0-10VDC. Coordinate signal output with controls installer.
   b. Transmitter to include an analog airflow gauge to provide direct analog readout in cfm. Mount on the outside of the air handler if air handler is located in a mechanical room. Mount in a NEMA 3R control cabinet if located outside.
   c. Device to provide switch selectable Modbus or Johnson N2 outputs.
   d. Device to be UL listed.
   e. The transmitter shall be powered by 24 VAC, shall include over-voltage and over-current protection, and shall include watchdog circuitry to ensure continuous operation following power failures and/or brown- outs.
   f. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.
   g. The transmitter shall include self-diagnostics and other features to ensure reliability and continued operation despite a limited failure. The transmitter shall automatically detect sensor damage and correctly calculate the average using the remaining functional sensor nodes, while reporting a system fault over the network and by local visual indication.
   h. All integrated circuits shall be industrial rated for operation down to -40°F (-40°C).
   i. The environmental operating temperature limits for the transmitter shall be -20°F to 120°F (-28.8°C to 48.8°C).

j. The system shall be factory tested prior to shipment and not require calibration or adjustment over the life of the equipment when installed in accordance to manufacturer's guidelines.
k. The Sensors shall be calibrated to NIST traceable standards.

8. Manufacturers: Ebtron, Paragon Controls, Dynasonics, or equal.

Q. LED Pilot Lights
1. Provide wall mounted pilot lights to indicate when operable windows may be opened or closed based on outdoor weather conditions as determined by BAS. Mount adjacent to main access door serving space with operable windows or adjacent to light switch, as shown on Architectural or Mechanical drawings. Coordinate final placement of pilot lights and color of cover plate with Owner's Representative.
2. Polycarbonate or steel wall box.
3. Wall plate color to match wall color. Color options to include: ivory, white, black or stainless steel.
4. Continuous color indication. LED lights, 20-25 mm diameter. One green light located above one red light.
5. Voltage as selected by BAS installer, 12-volt or 24-volt, 20 mA, maximum.
6. Manufacturers: Signaworks #WP22 Series or equal.

R. Flow Switch
1. Paddle type vane flow switch for insertion into pipe sizes 1" to 8". Forged brass body, stainless steel vane, and tin-bronze bellows. Maximum operating temperature to 230°F (110°C) and maximum operating pressure to 145 psig (10 bar). NEMA 4 enclosure, SPDT snap switch, 250 VAC (max). Connection using 1" male NPT or BSPT. Switch must be installed vertically on a horizontal pipe run.
2. Manufacturers: Dwyer #FS-2, or equal.

2.9 ACTUATORS

A. Electronic Actuators:
1. Size for torque required for damper seal at load conditions.
2. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
3. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
4. Overload protected electronically throughout rotation.
5. Fail-Safe Operation: Mechanical, spring-return mechanism
6. Electronic Fail-Safe Operation: Incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10% increments. The electronic fail safe shall have a 2-10 second adjustable operational delay.
7. Power Requirements (Spring Return): 24-V ac, maximum 10 VA at 24-V ac or 8 W at 24-V dc (running). Maximum 1 VA at 24-V ac or 1 W at 24-V dc (holding).
8. Proportional Actuators shall be fully programmable through an onboard EEPROM by using an external cable and software interface.
9. Temperature Rating: -22 to +122ºF.
10. Housing: Minimum requirement NEMA type 2 mounted in any orientation. .
11. Agency Listings: ISO 9001, cULus, CE or CSA
12. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
13. Manufacturers: Belimo, Siemens, Honeywell, Keystone #777, or equal.

B. Actuators with torque requirements exceeding 360 inch-pounds:
1. The combination of valve and actuator shall meet the close-off requirements as specified in Section 2.16.H – Butterfly Valves.
2. Coupling: ISO 5211 mounting standards.

3. Overload Protection: A self-resetting thermal switch embedded in the motor.
4. Manual Override: Actuator shall be equipped with a hand wheel or shaft for manual override to permit operation of the actuator in the event of an electrical power failure
5. Power Requirements: 24VAC, 120VAC, or 230VAC single phase.
6. Auxiliary Switches: 2 SPDT rated 3A at 250 VAC.
7. Temperature Rating: -22 to +122ºF.
8. Duty Cycle Rated 75% minimum.
9. Housing: Minimum requirement NEMA type 4X/ IP67 with an industrial quality coating. Actuator shall have an internal heater to prevent condensation within the housing. A visual indication beacon shall indicate position status of the device.
10. Agency Listing: ISO, CE, CSA
11. The manufacturer shall warrant for 2 years from the date of production.
12. Manufacturers: Belimo, Siemens, Honeywell, or equal.

2.10 CONTROL VALVES

A. Manufacturer: Belimo, Siemens, Honeywell, or equal.

B. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional (except as noted).

C. Control Valve Actuators:
1. Size for valve close off at 150 percent of total system (head) pressure for two-way valves; and 100 percent of pressure differential across the valve or 100 percent of total system (pump) head differential pressure for three-way valves.
2. Coupling: directly couple and mount to valve stem, shaft ISO-style direct-coupled mounting pad.
3. Non-spring return actuators shall have manual override
4. Spring return actuators of 90 inch-pounds or above shall have manual override.

D. Control Valves:
1. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
2. Close-Off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system head pressure for two-way valves and 150 percent of the design pressure differential across the three-way valves.
3. The control valve assembly shall be provided and delivered from a single manufacturer as a complete assembly.

E. Pressure Independent Control Valves:
1. NPS 2 and Smaller: Forged brass body rated at no less than 400 PSI, chrome plated brass ball and stem, female NPT ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc for equal percentage characteristic.
2. NPS 2-1/2 through 6: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.
3. The control valve assembly shall have an integral magnetic flow meter Magnetic flow meter to accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSID across the valve with a valve body accuracy of +/- 5% variance due to differential pressure fluctuation or +/- 10% total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.
4. Flow Characteristics: NPS 1/2” through 2” Equal percentage characteristic. NPS 2-1/2” through 6” capable of Equal percentage or Linear characteristic (field programmable).

5. All proportional actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
6. Actuators for 3-wire floating (tri-state) and on 2 position (on/off) on 1/2" to 1" pressure independent control valves shall fail in place.
7. Water Coil optimization 2-1/2" through 6" shall be accomplished by utilizing an energy meter (a pressure independent control valve assembly) with two integral temperature sensors providing feedback of coil inlet and coil outlet water temperature; and integral magnetic flow meter for control and to provide actual analog flow feedback. Valve assembly to have built in intelligence to control pressure independently and a Delta T Manager mode to mitigate low delta T syndrome by referencing an internally programmed design delta T setpoint. Valve assembly shall be capable of communicating data by means of BACnet MS/TP, BACnet I/P and TCP IP. Data to include, but not be limited to, inlet and outlet coil water temperatures, valve position, absolute flow, absolute valve position, absolute power and heating/cooling energy in BTU/hr. Valve assembly shall be capable of trending and storing up to 13 months of data on the actuator. Trended data on actuator to be retrievable via TCP IP or direct connect and download to *.csv file format.
8. The manufacturer shall provide a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC).
9. The control valve shall require no maintenance and shall not include replaceable cartridges.
10. NPS 2" and smaller pressure independent control valves for individual coil control shall be provided as part of a pipe package supplied by the valve manufacturer. The supply side of the coil shall contain an integrated isolation ball valve/manual air vent with strainer/shut-off valve/drain with pressure/temperature test ports. The return side shall contain a union fitting with a pressure/temperature test port, pressure independent control valve, and integrated isolation ball valve/manual air vent with a pressure/temperature test port. Shut-off valves as an integrated part of the pressure independent control valve are prohibited. A braided stainless flexible hose shall be provided for each coil supply and return connection for all pipe packages.

F. Characterized Control Valves:
1. NPS 1/2" and smaller for Terminal Units: Nickel plated forged brass body rated at no less than 600 psi WOG Water oil gas, chrome plated brass Stainless steel stem is an option ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-Ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.
2. NPS 1" through 2": Nickel-plated forged brass body rated at no less than 400 psi, stainless steel ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.
3. NPS 2-1/2" through 6": GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball, stainless steel blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring package design, PTFE seats, and a stainless steel flow characterizing disc.
4. Flow Characteristics: Equal percentage characteristics.

G. Butterfly Valves – Resilient Seat:
1. NPS 2 to 12: Valve body shall be full lugged cast iron 200 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. The shaft shall be supported at four locations by RPTFE bushings.
2. NPS 14 and Larger: Valve body shall be full lugged cast or ductile iron, 150 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual-pin method to prevent the disc from settling onto the liner. The shaft shall be supported at four locations by RPTFE bushings.
3. Sizing:
   a. Two-Position: Line size or size using a pressure differential of 1 psi.

b. Modulating: 4 psig or twice the load pressure drop, whichever is more. Size for the design flow with the disc in a 60-degree-open-position and a design velocity not to exceed 12 feet per second.

4. Close-Off Pressure Rating: NPS 2-12” 200 psi bubble tight shut-off. NPS 14 and larger, 150 psi bubble tight shut-off.

H. Butterfly Valves – High Performance:

1. Valve body shall be full lugged carbon steel ANSI Class 150 [300] body with a 316 stainless steel disc without a nylon coating, RTFE seat, and be ANSI Class 150300 flange standards. Blowout-proof shaft shall be 17-4ph stainless steel and shall be supported at four locations by glass-backed TFE bushings. Valve packing shall be Chevron TFE and shall include fully adjustable packing flange and separable packing gland. Valve body shall have long stem design to allow for 2” insulation (minimum). Valve face-to-face dimensions shall comply with API 609 and MSS-SP-68. Valve assembly shall be completely assembled and tested, ready for installation.
2. Sizing:
   a. Two-Position: Line size or size using a pressure differential of 1 psi.
   b. Modulating: 4 psig, or twice the load pressure drop, whichever is more. Size for the design flow with the disc in a 60-degree-open-position with the design velocity less than 32 feet per second.
3. Flow Characteristics: Modified equal percentage, unidirectional.
4. Close-Off Pressure Rating: 150 psi bubble tight shut-off.
5. Media Temperature Range: ANSI Class 150 limitations.
6. Max Differential Pressure: 285 psi @ 100°F for ANSI 150 (725 psi @ 100°F for ANSI 300).

2.11 DOMESTIC WATER SECURITY VALVES

A. Scope: connect to BAS for automatic opening and closing of domestic cold water supply to building.

B. Control Valve Actuator:

1. High torque actuator, fast opening and closing to control incoming domestic cold water service.
2. NEMA 6P waterproof enclosure.
3. UL listed.
4. Power supply input:100–240 volts, 60 Hz, 1 amp maximum. Output 18 volts, 2.22 amps.
5. BAS feedback signals for valve open or closed.
6. 12 VDC trigger contact to open valve.

C. Control Valve:

1. 316 stainless steel, 3-piece construction for body, ball and stem.
2. Equipped with a manual handle for emergency override.
3. Pressure rated to 600 psi, minimum.
4. Full port ball valve.
5. Threaded for sizes 1/2” to 2”.

D. Low lead and certified for potable water use per UPC and NSF/ANSI 61.

E. Manufacturer: Automatic Security Valves, or equal.

2.12 WIRELESS SYSTEM

A. Architecture and Communications:

1. Wireless equipment controllers and control devices shall conform to IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems. Equipment shall also comply with the following standards:
   1) UL 916: Energy Management Equipment

2) UL 94: The Standard for Flammability of Plastic Materials for Parts in Devices and Appliances: 5 VA flammability rating
3) UL 873: Temperature regulating and indicating equipment
4) ZigBee Building Automation
5) BACnet Tunneling

2. Communication between equipment controllers shall conform to ZigBee Building Automation (ZBA) standard as BACnet tunneling devices to ensure future integration of other ZBA certified devices.
3. Operating range shall be a minimum of 200 feet; open range shall be 2,500 ft. (762 m) with less than 2% packet error rate to ensure reliable operation.
4. To maintain robust communication, mesh networking and two-way communications shall be used to optimize the wireless network health.
5. Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.
6. Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES – Section 15.247 & Subpart E.
7. The system devices shall use direct sequence spread spectrum RF technology.
8. The system devices shall operate on the 2.4 GHZ ISM Band.
9. The system devices shall be FCC compliant to CFR Part 15 subpart B Class A.

B. Service Tools:
1. To support network setup and troubleshooting, service tools shall display link quality and hop quantities for each wireless device.
2. Wireless service tool access to communication link shall be provided to minimize installation and troubleshooting labor.

C. Construction:
1. Devices such as sensors, receivers and signal coordinators, intended to be installed in a return air plenum, shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB. Wall mounted devices may be assembled in NEMA-1 plastic enclosures.

D. Wireless Field Bus System:
1. The system shall employ ZigBee technology to create a wireless mesh network to provide wireless connectivity for BACnet devices at multiple system levels. This includes communications from field controllers to sensors and from sensors to field controllers. Wireless devices shall co-exist on the same network with hardwired devices. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.
2. The field bus coordinator shall provide a wireless interface between supported field controllers and an NAE35/45/55 or NCE25 supervisory controller via the BACnet MS/TP field bus. Each wireless mesh network shall be provided with a coordinator for initiation and formation of the network
   a. The coordinator shall operate as a bidirectional transceiver with the sensors and routers to confirm and synchronize data transmission.
   b. The coordinator shall be capable of communication with sensors and routers up to a maximum distance of 250 Feet (line of sight).
   c. The coordinator shall have LED indicators to provide diagnostic information required for efficient operation and commissioning.
3. A wireless field bus router shall be used with any controller and field device to provide a wireless interface to supervisory devices and associated wireless mesh room temperature sensors.
   a. The router shall operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.
   b. The router shall be capable of communication with other mesh network devices at a maximum distance of 250 feet (line of sight).

c. The router shall provide LED indication for use in commissioning and troubleshooting that can be disabled.

E. Wireless Room Temperature Sensors:
1. Wireless space sensors shall be capable of continuous operation in the following conditions:
a. Ambient operating temperature range shall be 32°F to 122°F (0 to 50°C).
b. Ambient operating and storage humidity range shall be 5 to 95%, non-condensing.
2. Wireless room temperature sensors shall sense and transmit room temperatures, room set point, room occupancy notification low battery condition to an associated router.
a. The sensors shall be available with:
1) Warmer/cooler setpoint adjustment or no setpoint adjustment.
2) Setpoint adjustment scale: 55°F to 85º F (minimum range).
b. Wireless sensors shall be provided with display of room temperature, signal strength, fan mode, occupancy and network status as required by application and indicated on plans or in the schedules.
3. Features:
a. The wireless space sensor battery life shall provide at least 15 years life under normal operating conditions and must be readily available size AA, 1.5V.
b. To check for proper operation, wireless space temperature sensors shall include signal strength on the space sensor display.
c. To support use by the physically impaired, the wireless space sensor shall be a minimum font size of 12 points, and the LCD model shall be readable in low light conditions.
d. An optional 2% relative humidity sensors module shall be available for humidity control applications to minimize the need for wired sensors, and shall not shorten typical battery life to less than 15 years.
e. Wireless space sensors shall be available as: temperature only, field configurable model with digital display, and optional 2% humidity module for use in either model above. The field configurable models shall all allow field configuration without a field service tool. Configuration options include: setpoint, override pushbuttons, fan speed, and system mode switches. System mode, fan speed and setpoint shall include a lock option. The digital display shall also be field configurable to display in Fahrenheit or Celsius units of measure, and can also be configured to display setpoint only.
f. The wireless space sensor addresses shall be held in non-volatile memory to ensure operation through system voltage disturbances and to minimize the risk of incorrect association.
g. The wireless space sensor shall be addressed using pushbuttons and display with numerical indication to simplify and reduce installation time and minimize risk of incorrect addressing.
h. The wireless space sensor shall include security screws to protect against theft.
4. Accuracy:
a. To ensure proper system performance, the wireless space sensors shall automatically determine when the space temperature is rapidly changing. When the space temperature is rapidly changing, the space temperature shall be transmitted at least once each 30 seconds. The maximum time between transmissions shall be 15 minutes. Space temperature sensing accuracy shall be +/- 0.5°F (+/- 0.28°C).

F. Wireless Communications Interface:
1. Wireless communication devices and receivers shall be capable of continuous operation in the following conditions:
a. Ambient operating temperature range shall be 32°F to 122°F (0 to 50°C).
b. Ambient operating and storage humidity range shall be 5 to 95%, non-condensing.
2. Features:

a. Wireless communications interface shall be addressed using rotary switches with numerical indication to simplify and reduce installation time and minimize risk of incorrect addressing.

G. Many-To-One Wireless Receiver:
1. The Many-To-One System Receiver shall receive wireless Radio Frequency (RF) signals containing temperature data from multiple wireless room temperature sensors.
2. The receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.
3. The receiver shall be capable of communication with sensors up to a distance of 200 Feet.
4. The receiver shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
5. The receiver shall have LED indicators to provide information regarding the following conditions:
a. Power: on/off.
b. Ethernet: receiver activity/no activity.
c. Wireless Normal Mode: transmission from sensors/no transmission.
d. Wireless Rapid Transmit Mode: no transmission/weak signal/adequate signal/excellent signal.
e. Ethernet Connection: No connection/10Mbps connection/100Mbps connection
f. Network Activity: No network activity/half-duplex communication/full-duplex communication.

H. One-to-One Wireless Receiver:
1. The One-To-One Wireless Receiver shall receive wireless radio frequency (RF) signals containing temperature data from multiple wireless room temperature sensors and communicate this information to field controllers via the communication bus.
2. The receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.
3. The receiver shall be capable of communication with from one to five sensors up to a distance of 200 Feet.
4. The receiver shall have LED indicators to provide information regarding the following conditions:
a. Power.
b. Communication Bus: Receiver activity/no activity.
c. Wireless RF: Transmission from sensors/no transmission.
d. Wireless Rapid Transmit Mode: No transmission/weak signal/adequate signal/excellent signal.

I. System Tools:
1. Wireless Space Sensor Installation and Configuration Tools
a. To enable installation and servicing when specialized tools are required, site survey and installation tools as well as software shall be provided to the contractor use for system installation and commissioning for the duration of the warranty period.
b. To enable installation and servicing when specialized tools are required, site survey and installation tools as well as software shall be provided to the Owner for permanent possession for ongoing system maintenance and trouble shooting.

2.13 ENCLOSURES

A. All controllers, power supplies and relays shall be mounted in enclosures.

B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment.

C. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.

D. Outdoor enclosures shall be NEMA 3R or NEMA 4X, as necessary for the site.

E. Enclosures shall have hinged, locking doors.

F. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 0.125 inches thick and appropriately sized to make label easy to read.

2.14 PROGRAMMABLE THERMOSTAT

A. Thermostat with 365 day programmability that allows the building occupants to program the temperature setpoints for at least four periods within 24 hours. A minimum of 5 holidays shall be programmable for up to 5 years. Daylight savings shall be provided as a standard feature in the programming calendar.
   1. Manufacturers: Honeywell VisionPRO 8000 Series, Honeywell Prestige THX 9000 Series, Honeywell TB7600 Series, Venstar ColorTouch T6000 Series, EnTouch Pro/One or equal.

B. Minimum thermostat features shall include, but not limited to, the following:
   1. The thermostat shall have a touch screen and shall display both room temperature and cooling and heating setpoints simultaneously, and shall indicate when cooling or heating and what stage is energized on the main screen.
   2. Programming may be accomplished at the thermostat, or via free software. The program shall have an override mode to provide comfort on demand while in an unoccupied period. The unoccupied override shall be adjustable by pushing an override button and selecting thirty minute increments, up to four hours.
   3. The setback override shall be activated by a single button, and deactivated on demand.
   4. Setpoints shall be adjustable from 35°F to 99°F, with a minimum 5°F adjustable deadband available.
   5. Dual setpoints shall be provided with the ability to individually set heating and cooling temperatures with adjustable heating and cooling setpoint limits. Initial occupied mode cooling setpoint of 75°F and heating setpoint of 70°F. Initial unoccupied mode cooling setpoint of 85°F and heating setpoint of 55°F.

C. The thermostat shall be capable of independently controlling an individual system, with up to three stages of heating and two stages of cooling, fan, and reversing valve.
   1. For heat pumps an adjustable auxiliary heat lockout temperature based on outdoor temperatures shall be provided.
   2. Emergency Heat switch will be provided on the touch screen when set in heat pump mode.

D. The fan shall be programmable to operate continuously during occupied periods and in auto mode during unoccupied periods.

E. Controls shall be capable of alternating compressor starting sequence with a built-in lead-lag operating logic.
   1. Equipment protection options shall be provided to prevent compressor short-cycling, and to limit the number of cycles per hour. These options shall be overridden for use with zoning systems.

F. Pre-Occupancy purge cycle that energizes the fan before the programmed occupancy time, adjustable up to three (3) hours in 15-minute increments.
   1. Configurable terminals shall be provided for remote indoor, remote outdoor or remote supply air temperature sensing.

G. Multiple security levels to limit access to programming and configuration and will allow for a custom passcode. The various security levels will allow controlled access to programming, unoccupied override, and thermostat mode.

H. All programming information, except time of day, shall reside in nonvolatile memory. During a power failure, the thermostat shall maintain its program indefinitely without the use of batteries.

Wi-Fi capable and controlled through local wireless internet routers. The thermostat shall be capable of receiving an automated demand response signal from the local electrical utility, and automatically reset the cooling and heating setpoints during the demand event. When the demand event is terminated by the local electrical power utility, the thermostat will reset to normal occupied and unoccupied setpoints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owner's Representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)

A. Install in accordance with manufacturer's instructions.

B. Provide all miscellaneous devices, hardware, software, interconnections, installation, and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum three (3) feet of clear access space in front of units. Obtain approval on locations from Owner's Representative prior to installation.

B. Wall mounted temperature sensors will typically be mounted directly above or below light switches and comply with ADA height requirements. Coordinate with Owner, Architect and other trades to assure proper mounted locations prior to installation.

C. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.

D. Identify all equipment and panels. Provide permanently mounted tags for all panels.

E. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

3.4 CONDUIT

A. Conduit Requirements: all conduit shall with comply with minimum requirements of local authority having jurisdiction.
   1. Low voltage wiring in concealed areas may be plenum rated. Low voltage wiring in exposed areas shall be enclosed in conduit.
      a. All low voltage wiring exposed to weather shall be installed in conduit.
      b. Low voltage wiring in exposed areas, such as in mechanical, electrical, or service rooms, shall be installed in EMT conduit up to 10 feet above finished floor.
   2. All low voltage control wiring in critical facilities and critical locations shall be enclosed in conduit.

B. Provide rigid conduit for low voltage wring in walls for all wall mounted sensors, CO2 sensors, humidity sensors, etc. Conduit shall be run to 6" (minimum) above the ceiling and shall terminate with a bushing installed on the conduit end. Flexible conduit shall not be used.

C. Provide conduit for low voltage wiring above inaccessible ceilings.

D. Conceal all conduits, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 12 inches (30 cm) from high-temperature equipment (i.e.-such as flues or high temperature pipes).

E. Conduit must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

F. Secure conduits with conduit clamps fastened to the structure and spaced according to code requirements. Conduits and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.

G. Size of conduit and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

3.5 LOW VOLTAGE INTERLOCKING AND CONTROL WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

B. All low-voltage wiring shall meet NFPA-70 (NEC) Article 725 Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.

C. Do not install Class 2 wiring (greater than 100 volts and protected by overcurrent device not over 20 amperes) in conduits containing Class 1 wiring (not exceeding 30 volts and 1000 volt-amperes). Boxes and panels containing line voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

D. Unless otherwise noted, power wiring for all valve and damper actuators is Class 2. If the BAS contractor desires to substitute 120-volt actuators, the BAS contractor shall coordinate directly with the General Contractor and Electrical Contractor to provide all 120-volt wiring and conduit at no additional cost to the Owner.

E. Contractor shall provide step-down transformers as necessary.

F. Install insulated bushings on all conduit ends and openings to enclosures. Seal top end of vertical conduits.

G. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block. Wire nuts are not acceptable.

H. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

I. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

J. Use color-coded conductors throughout with conductors of different colors.

K. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

L. The contractor shall terminate all communications, control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

3.6 COMMUNICATION WIRING

A. The contractor shall adhere to the wiring requirement previously listed.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

C. Do not install communication wiring in conduits and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer’s instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

J. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
   1. The network shall use shielded, twisted-pair or stranded cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot). Wire gauge and wire type shall be sized and coordinated with manufacturer load requirements and lengths of runs.
   2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
   3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
   4. An MS/TP EIA-485 network shall have no T connections.

K. All Ethernet cabling, routers, hubs and switches for connecting 230900 furnished and installed control panels, servers and clients to the building Owner’s Ethernet network are the responsibility of the BAS contractor.

3.7 MOTORIZED DAMPERS

A. Where ducts penetrate an exterior surface install a Class I motorized damper at each outdoor air supply opening, return air opening, exhaust opening, relief outlet, shaft vent and stairway vent, as required to comply with minimum requirements of the local Energy Code.
   1. Dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the system served requires outdoor air or exhaust air or operates continuously or the dampers are opened to provide intentional economizer cooling.

2. Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

3.8 FIELD SERVICES

A. Prepare and start logic control system under provisions of this section.

B. Start up and commission systems. Allow sufficient time for startup and commissioning prior to placing control systems in permanent operation. Provide all labor and services as necessary to support testing and verification by third party commissioning authority.

C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for one year or as specified.

D. Provide Owner's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.9 PROJECT RECORD DOCUMENTS

A. Project Record Documents: Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:
1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on optical media and as 11" x 17" prints.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Part 3: "Control System Demonstration and Acceptance."
3. Operation and Maintenance (O & M) Manual.
4. As-built versions of submittal product data.
5. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
6. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
9. Documentation of all programs created using custom programming language including setpoints, tuning parameters, and object database.
10. Graphic files, programs, and database on magnetic or optical media.
11. List of recommended parts with part numbers and suppliers.
12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

3.10 TRAINING

A. Provide application engineer to instruct Owner in operation of systems and equipment.

B. Provide system operator's training to include (but not be limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of three persons.

C. Provide on-site training above as required, up to 16 hours as part of this contract.

D. Provide tuition for at least one individual to attend for a one-week factory training class. If applicable, costs for travel, lodging and meals will be the responsibility of the Owner.

3.11 DEMONSTRATION

A. Demonstrate complete operating system to Owner's Representative.

B. Provide certificate stating that control system has been tested and adjusted for proper operation.

END OF SECTION 230900

SECTION 232300

REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. Includes, but not limited to:
   1. Furnish and install piping and piping specialties for refrigeration systems serving split system air conditioning units.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230719: HVAC Piping Insulation.

C. Section 238126: Split Gas Furnace/Air Conditioning Units.

D. Section 238145: Split Heat Pump Units.

E. Section 238158: VRF-VRV Systems.

F. Division 26: Electrical.

1.3 QUALITY ASSURANCE

A. Codes and Standards: Comply with the requirements of the latest addition of the following:
   1. Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications" latest edition.
   2. ASHRAE 15: Safety Code for Refrigeration Systems.
   3. ASME B31.5: Refrigeration Piping and Heat Transfer Components.
   4. ASTM B 280: Specification for Seamless Copper Tube for Air Conditioning & Refrigeration Field Service.

B. Contractor Qualifications: A refrigeration contractor licensed by the State shall install refrigerant piping.

C. Manufacturer Qualifications:
   1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
   2. Replacement parts shall be readily available and stocked in the USA.
   3. Manufacturer shall have a minimum of five years of manufacturing products related to refrigerant piping and/or fittings.
   4. Products shall have an installation history of no less than five years of field operation with reliable maintenance track record.
   5. Alternate system and material must be submitted with historical supporting documentation and reliability report before approval is allowed.

D. Codes and Standards:
   1. All work shall be in full accordance with all applicable codes, ordinances and code rulings.
   2. The Contractor shall furnish without any extra charge the labor and material required for compliance of codes for work required, but not specifically shown in Drawings.
   3. Perform all tests required by governing authorities and as required under all Division 23 Sections. Provide written reports on all tests.
   4. Electrical devices and wiring shall confirm to the latest standards of NEC; all devices shall be UL listed and so identified.

E. Product Control
   1. Protection: Use all means necessary to protect materials before, during, and after installation and to protect the installed work and materials of all other trades.
   2. The general arrangement and locations of piping are shown on the Drawings. Changes may be necessary to accommodate work. Should it be necessary to deviate from arrangement or location indicated in order to meet existing conditions or due to interference with work of other trades, such deviations as offsets, pipe sizes, fittings sizes, rises and drops in piping that may be necessary, whether shown or not, shall be made without extra expense. Accuracy of data given herein and on the Drawings is not guaranteed. The Drawings and Specifications are for assistance and guidance, and exact locations, distances, and elevations will be governed by actual site conditions.
   3. All work shall be in accordance with the applicable codes listed in Division 01. No extra charge will be paid for furnishing items required by the regulations but not specified herein or shown on the Drawings. Should there be any direct conflict between the Drawings and/or Specifications and the above rules and regulations, the rules and regulations shall take precedence.
   4. All work shall be completely coordinated, and all lines, grades, slopes and vertical and horizontal locations of pipes shall be exactly determined in the field and cleared with the Owner's Representative before the installation of these items is begun. No extra compensation shall be made for failure to observe this clause.
   5. The Drawings and Specifications do not undertake to list every item that will be installed. When an item is necessary for the satisfactory operation of the system, it shall be furnished without extra cost. Work called for in the Specifications, but not on the Drawings, or vice versa, shall be done as though required by both. Lack of specific mention of any work necessary for proper completion of the work in the Specifications and/or Drawings, shall not lessen the Contractor's responsibility.
   6. Obtain Owner's Representative's approval prior to rerouting of existing services. Refer to Division 01 sections for alterations, shutdown and temporary construction for existing services.
   7. Pipe spaces provided in the design shall be utilized and the work shall be kept within the spaces established on the Drawings.
   8. Manufacturers' directions shall be followed in all cases where manufacturers of articles used in this Contract furnish directions covering points not shown on the Drawings or specified herein. Manufacturers' directions do not take precedence over the Drawings and Specifications. Where manufacturers' directions are in conflict with the Drawings and Specifications, submit these conflicts to the Owner’s Representative and receive clarification before installing the work.
   9. Do not permit or cause any work to be covered or enclosed until it has been inspected, tested, and approved. Should any of the work be enclosed or covered before inspection and test, Contractor shall, at his/her own expense, uncover the work; and, after it has been inspected, tested and approved, make all repairs with such materials as may be required. Restore all work to its original and proper condition.
   10. Be responsible for damage to any of this work before acceptance. Securely cover all openings, both before and after setting into place, to prevent obstructions in the pipes and breakage.
   11. Repair all damage to the premises occasioned by the work. All damage to any part of the premises caused by leaks or breaks in the pipe installed under this Section of the work for a period of one (1) year after date of final acceptance of the work, shall be repaired.

F. All materials (such as insulation, ductwork, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for all refrigerant piping, valves and specialties indicating dimensions, flow capacity, pressure setting, tolerances etc.

B. Shop Drawings:
1. Submit shop drawings including plans, schematics, and riser diagrams of refrigerant piping, including dimensions of all piping.
2. Reference to associated insulation systems submitted in compliance with Section 230719 HVAC Piping Insulation.
3. Provide all details of suspension and support for ceiling hung equipment.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, valve replacement, and spare parts lists. Include this data, product data, and shop drawings in operating and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect equipment and products against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.6 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Provide the following additional extended warranty requirements that apply to piping with mechanical type joints and fittings, such as grooved or pressed/compression type fittings.
1. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.
2. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.
3. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:
1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).

B. Line Test Pressure for Refrigerant R-407C:
   1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
   2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
   3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

C. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
   2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
   3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

D. Do not use pre-charged refrigerant lines more than 50 feet in length.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B88, Type K or L; or ASTM B280, Type ACR.

B. Wrought-Copper Fittings and Unions: ASME B16.22.

C. Solder Filler Metals: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

D. Flux: Stay-Silv white brazing flux by J.W. Harris Co or silver solder flux by Handy & Harmon.

E. Brazing Filler Metals: AWS A5.8.
   1. Copper to Copper Connections:
      a. AWS Classification BCuP-4 Copper Phosphorus (6% silver).
      b. AWS Classification BCuP-5 Copper Phosphorus (15% silver).
   2. Copper to Brass or Copper to Steel Connections
      a. AWS Classification BAg-5 Silver (45% silver)
   3. Do not use rods containing Cadmium.

F. Manufacturers: Mueller Streamline, Nibco, Grinnell, Elkhart, or equal.

2.3 FLEXIBLE CONNECTORS

A. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.

B. End Connections: Socket ends.

C. Offset Performance: Capable of minimum 3/4 inch (20 mm) misalignment in minimum 7 inch (180 mm) long assembly.

D. Working Pressure Rating: Factory test at minimum 450 psig (3100 kPa).

E. Maximum Operating Temperature: 250°F (121°C).

F. Manufacturers: Metraflex #RAF or equal.

2.4 COPPER PRESS-CONNECT TYPE FITTINGS AND JOINTS – IN JURISDICTIONS WHERE 2018 MECHANICAL CODE IS ADOPTED

A. Flame free press fittings are allowed as a contractor option, however confirm compliance with allowable refrigerant usage, and local building codes authority having jurisdiction.

B. Product Characteristics (minimum):
   1. Continuous Operating Temperature: 250°F (121°C).
   2. O-Ring Temperature Rating: -40 to 300°F (-40 to 149°C).
   3. Maximum Rated Pressure: 700 psi (49 bar).
   4. Minimum Burst Pressure: 2,100 psi (145 bar).

5. Vacuum Pressure Capability: 20 micron.
6. Maximum Leak Rate: 0.1 oz Helium per year.
7. Vibration Resistance: Conforms to UL 109.

C. Klauke 15 kN Compatible Jaws: Hard Drawn Copper: 1/4" to 7/8" Type ACR, M, L, Type K up to 7/8". Soft (Annealed) Copper: 1/4" to 1-1/8" Type ACR, L, Type K up to 7/8".

D. Klauke 19 kN Jaws and RIDGID Compatible Jaws: Hard Drawn Copper: 1/4" to 1-3/8" Type ACR, M, L, K. Soft (Annealed) Copper: 1/4" to 1-3/8" Type ACR, L, K.

E. Tubing: The installer shall confirm the copper tubing conforms to ASTM B280, ASTM B88, or EN 12735-1.

F. Fitting Body: Conform to ASTM-B75 or ASTM-B743.

G. Fitting Sealing O-Rings: HNBR. These shall be factory installed only.

H. Compatible ODM Fittings: Material conform to C12200 copper per ASTM B280 or Cu-DHP CW024A per BS EN 12735-1.

I. Threaded Schraeder Valve Access Fittings: Schraeder style valve material and threads conform to SAE J513.

J. Threaded Fittings: Flare nuts conform to SAE J513 & SAE J533.

K. Manufacturers: Parker Sporlan #Zoomlock or approved equal.

2.5 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.

B. Wrought-Steel Fittings: ASTM A234, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

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

E. Flanged Unions:
1. Body: Forged-steel flanges for NPS 1” to NPS 1-1/2” (DN 25 to DN 40) and ductile iron for NPS 2” to NPS 3” (DN 50 to DN 80). Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch (180-mm) long assembly.
6. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
7. Maximum Operating Temperature: 330°F (165 C).

F. Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
2. End Connections:
   a. NPS 2” (DN 50) and Smaller: With threaded-end connections.
   b. NPS 2-1/2” (DN 65) and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch (180-mm) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250°F (121°C).

G. Manufacturers:
1. Anaconda "Vibration Eliminators" by Anamet.
2. Vibration Absorber Model VAF by Packless Industries.
3. Vibration Absorbers by Superior Valve Co.
4. Style "BF" Spring-flex refrigerant connectors by Vibration Mountings.
5. Or equal.

2.6 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 F (135 C).

B. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 F (135 C).

C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 F (135 C).

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Manufacturers: Apollo Valves (Conbraco), Henry, Mueller, Superior, Virginia, or equal.

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
1. Body and Bonnet: Plated steel.

2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24/115/208-volt ac coil as required.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 F (116 C).

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 F (116 C).

G. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Reverse-flow option (for heat-pump applications).
6. End Connections: Socket, flare, or threaded union.
7. Manufacturers: Alco, Henry, Mueller, Parker, Singer, Sporlan, or equal.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter and 24/115/208-volt AC coil as required.
7. End Connections: Socket.
8. Throttling Range: Maximum 5 psig (34 kPa).
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 F (116 C).

I. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 F (135 C).

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 275 F (135 C).

K. Moisture/Liquid Indicators:
1. Body: Forged brass.

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 F (116 C).

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10-micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement for suction-line filter dryers.
6. Maximum Pressure Loss: **2 psig (14 kPa)**.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 240 F (116 C).

M. Permanent Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10-micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: **2 psig (14 kPa)**.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 240 F (116 C).
9. Manufacturers: Alco, Mueller, Parker, Sporlan, Virginia, or equal.

N. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 F (135 C).

O. Receivers: Comply with AHRI 495.
1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL for receivers larger than 6 inches (150 mm).
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 F (135 C).

P. Liquid Accumulators: Comply with AHRI 495.
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 F (135 C).

Q. Sight Glass
1. Combination moisture and liquid indicator with protection cap.

2. Sight glass shall be full line size.
3. Sight glass connections shall be solid copper or brass, no copper-coated steel sight glasses allowed.
4. Manufacturers: Alco, Asco, Mueller, Parker, Sporlan, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide and install refrigerant piping, fittings, valves and devices as required by equipment manufacturer and as shown on the Drawings.

B. Refrigeration system connections shall be copper-to-copper, copper-to-brass, or copper-to-steel type properly cleaned and brazed with specified rods. Use flux only where necessary.
1. No soft solder (tin, lead, antimony) connections will be allowed in system.
2. Braze valve, sight glass, and flexible connections.
3. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.

C. Insulate all suction and hot gas lines. Insulate liquid lines where pipe may be in close contact to humans.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at refrigerant piping connection to all equipment (coils, condensers, and/or compressors) as required by the manufacturer and where necessary to prevent vibration from transferring into the building structure and to minimize vibration and audible noise in occupied spaces.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective chaseway where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.

3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Install sleeves and escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

C. Steel pipe: Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel 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 to restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 PRESS-FIT PIPING INSTALLATION-ZOOMLOCK (CONTRACTOR OPTION)

A. Installers shall follow all installation steps per the Sporlan #Zoomlock installation instructions. This covers examination, preparation and installation.

B. Upon delivery to the jobsite, the installing contractor shall examine the copper tubing and fittings for debris, defects, incise marks (manufacturer's engraving on tube), holes or cracks.

C. If any brazing is required, the installer shall follow the manufacturer guidelines.

D. Wrapping electrical tape over the end of a flare fitting can be used when placing foam insulation of a pipe to prevent tearing.

E. The installer shall not crimp Sporlan #Zoomlock fittings over flared style tubing (ODF). The installer can cut off the flare and crimp the Sporlan #Zoomlock fitting to the tube as long as there is a minimum of two inches of tube remaining.

F. Installer shall ensure piping is spaced such that the crimp gauge can be fit around the pipes to check for proper crimp.

G. The installer shall place Sporlan #Zoomlock fittings no closer than 1" apart.

H. The installer shall locate the copper tubing such that the crimp tool and jaws can fit around the fittings.

3.6 HANGERS AND SUPPORTS

A. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Spring hangers to support vertical runs.
3. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

B. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
1. Up to NPS 5/8”(DN 18): Maximum span, 60” (1500 mm); minimum rod, 3/8” (9.5 mm).
2. Greater than 5/8” up to NPS 1-1/8” (DN 25): Maximum span, 72” (1800 mm); minimum rod, 3/8” (9.5 mm).
3. Greater than 1-1/8” up to NPS 2” (DN50): Maximum span, 96” (2400 mm); minimum rod, 3/8” (9.5 mm).
4. NPS 2-1/2” (DN 65): Maximum span, 108” (2700 mm); minimum rod, 3/8” (9.5 mm).
5. NPS 3” (DN 80): Maximum span, 10 feet (3 m); minimum rod, 3/8” (9.5 mm).
6. NPS 4” (DN 100): Maximum span, 12 feet (3.7 m); minimum rod, 1/2” (13 mm).

C. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2” (DN 50): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
2. NPS 2-1/2” (DN 65): Maximum span, 11 feet (3.4 m); minimum rod, 3/8 inch (9.5 mm).
3. NPS 3” (DN 80): Maximum span, 12 feet (3.7 m); minimum rod, 3/8 inch (9.5 mm).
4. NPS 4” (DN 100): Maximum span, 14 feet (4.3 m); minimum rod, 1/2 inch (13 mm).

D. Support multifloor vertical runs at each floor.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
4. Prepare test and inspection reports.

3.8 SYSTEM CHARGING

A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).

4. Charge system with a new filter-dryer core in charging line.

3.9 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113

AIR DISTRIBUTION

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
1. Ductwork - Rigid, Flexible and Fabric.
2. Diffusers, Grilles, and Registers.
3. Ductwork Specialties.
4. Flexible Connections.
5. Sealants, Adhesives and Tapes.
6. Duct Access Panels and Doors.
7. Backdraft and Relief Dampers.
8. Constant Volume Regulator.
9. Variable Air Volume (VAV) Terminal Units.
10. Combination Fire and Smoke Dampers.
11. Fire Dampers.
12. Smoke Dampers.
13. Chimneys, Stacks and Flue Vents.
14. Control Dampers.
15. Fan Powered Terminal Units.
16. Louvers.
17. Flashings.
18. Bird Screens.
19. Sound Traps.
20. Elevator Shaft Vents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic Materials and Methods.

B. Section 230593: Testing, Adjusting and Balancing.

C. Section 230713: Duct Insulation.

D. Section 230900: Building Automation System (BAS) Control.

E. Division 26: Electrical.

1.3 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
1. ARI 885-98: Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminal and Air Outlets.
2. AMCA-210: Laboratory Methods of Testing Fans for Rating Purposes.
3. ANSI S12.23: Designation of Sound Power Emitted by Machinery and Equipment.
4. ASC-A7001: Standard for Duct Sealants.
5. ASHRAE Standard 130: Methods of Testing Air Terminal Units.
6. AHRI Standard 885: Procedures for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.
7. NFPA 90A: Standards for the Installation of Air Conditioning and Ventilating Systems.
8. NFPA 90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

9. American Society for Testing and Materials (ASTM): Manufacture and test in accordance with the ASTM Standards, including:
   a. ASTM A167: Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. Type 304 or 304 stainless steel.
   b. ASTM A525: Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) Hot-Dip Process. G60 and G90 zinc-coated.
   c. ASTM A527/A527M: Standard Specification for Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.
   d. ASTM C920: Standard Specification for Elastomeric Joint Sealants.
10. Underwriters Laboratory (UL): Manufacture and test in accordance with the UL Standards, including:
   a. 181:Standard for Factory-Made Air Ducts and Air Connectors.
   b. 181A: Standard for Closure Systems for Use With Rigid Air Ducts.
   c. 181B: Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors.
   d. 268A: Standard for Smoke Detectors for Duct Application.
   e. 555: Standard for Fire Dampers.
   f. 555C: Standard for Ceiling Dampers.
   g. 555S: Standard for Smoke Dampers.
   h. 723: Standard for Test for Surface Burning Characteristics of Building Materials.
   i. 2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

B. Provide and construct ductwork systems in conformance with the latest editions of the following documents:
   1. SMACNA HVAC Duct Construction Standards-Metal and Flexible.
   2. SMACNA HVAC Air Duct Leakage Test Manual.
   3. SMACNA HVAC Phenolic Duct Construction Standards.
   4. SMACNA - Accepted Industry Practice for Industrial Duct Construction" for duct pressures above +5" w.g. positive pressure or below -5" w.g. negative pressure. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the two standards.
   5. ASHRAE Systems and Equipment Handbook "Duct Construction" chapter.
   6. ASHRAE Fundamentals Handbook "Duct Design" chapter.

C. Alternatives: The SMACNA standards and publications referenced in this Section of the specifications establish ductwork construction requirements.
   1. Alternatives to these standards and publications may be submitted. Approval will be based on demonstration that such alternatives are equivalent and satisfy the functional requirements described in the referenced standards.
   2. Such demonstration shall include evidence that the alternatives proposed were tested in accordance with SMACNA procedures and with test results certified by an independent testing laboratory.

D. All ductwork and equipment shall be seismically supported and braced to meet or exceed the minimum requirements of “SMACNA Seismic Restraint Manual-Guidelines for Mechanical Systems” and local building code requirements.

E. Flame/Smoke Rating: All materials, including sealants and adhesives, exposed within plenum shall be noncombustible or have a flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. All materials installed within a plenum shall meet these requirements or have a safety data sheet available to indicate that materials are non-combustible. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Discrete plumbing, mechanical, and electrical

products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

1.4 DEFINITIONS

A. Class 0: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a surface burning characteristic of zero. Typically constructed of semi-rigid corrugated aluminum. This does not include sheet metal ductwork constructed per SMACNA Standards.

B. Class 1: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a flame spread index of not over 25 and a smoke developed index of not more than 50. Typically constructed of flexible ductwork, rigid fiberglass ductwork and plastic ductwork. This does not include sheet metal ductwork constructed per SMACNA Standards.

C. Flexible Air Duct (Factory-Made): Class 0 or Class 1 air ducts tested in accordance with 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Flexible ducts shall not be installed to serve more than two stories and shall not penetrate a fire-resistance rated assembly or construction. Maximum lengths of flexible ductwork shall not exceed lengths identified in this section or as limited by the AHJ, whichever is shorter.

D. Flexible Duct Connector (Factory-Made): Class 0 or Class 1 connectors tested in accordance with 12 of 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Connectors include, but are not limited to, short flexible connections between air handlers and ductwork systems, uninsulated transition fittings, specialty shapes for diffuser connections, etc. Connectors shall not penetrate a wall, floor, or ceiling. Maximum lengths of flexible ductwork shall not exceed five foot (5') lengths or as limited by the AHJ, whichever is shorter.

1.5 SUBMITTALS

A. Prior to construction, submit for approval on all materials and equipment:
1. Ductwork - Rigid, Flexible and Fabric.
2. Ductwork Specialties.
3. Flexible Connections.
4. Sealants, Adhesives and Tapes.
5. Flashings.
6. Bird Screens.
7. Duct Access Panels and Doors.
8. Backdraft Dampers.
9. Control Dampers.
10. Diffusers, Grilles, and Registers.
11. Fire/Smoke Dampers - Schedule of selected dampers must include the location, nominal size, free area velocity, and static pressure drop at free area velocity for each damper.
12. Sound Traps.
13. VAV Boxes.
14. SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

B. Shop Drawings: Provide shop drawings of sheet metal ductwork and plenums as follows:
1. Draw to a scale not less than 1/8" to one foot, with sheet sizes equal to Contract Drawings.
2. Show duct sizes, where possible use even duct sizes.
3. Show fitting details.
4. Show coordination with lighting fixtures, fire dampers, fire/smoke dampers, piping, diffusers, grilles, registers, fans, major electrical runs, cable trays and bus ducts.

C. Shop Drawings: Provide shop drawings for field erected mechanical equipment:
1. Draw to a scale of 1/2" to one foot, with sheet sizes equal to Contract Drawings.
2. Show plan, sections, elevations and details of all joints and enclosures.
3. Detail access doors and hardware.

4. Detail coil, damper, humidifier, filter and fan installations.
5. Show access space for electrical components that are part of the equipment provided and/or installed such as power and control panels on humidifiers. This shall be coordinated with Division 26 and NEC.

D. Certifications: Provide a duct schedule, certified by an officer of the sheet metal fabrication subcontractor, that the ductwork conforms to SMACNA standards, and for each sheet metal system furnished on the project include:
1. System name.
2. Duct material.
3. Duct gauge.
4. SMACNA rectangular reinforcement number.
5. SMACNA intermediate reinforcement number.
6. SMACNA transverse reinforcement number.
7. Rod diameter and type.
8. Sealant type.
9. Attachment method.
10. Duct system design pressure.

E. Construction IAQ Management Plan: Collaborate with the general contractor to submit and implement an IAQ Management Plan for the construction process meeting the requirements of the SMACNA IAQ Guidelines. This plan should address the protection of the ventilation system components during construction and cleanup of contaminated components after construction is complete. SMACNA IAQ Guideline recommends control measures in five areas. The IAQ Management Plan should address how compliance has been achieved in these required five areas as follows:
1. HVAC Protection
   a. Shutdown of return side of existing HVAC system in areas affected by heavy construction.
   b. Provision of temporary filters if existing or new systems must remain operational during construction.
   c. Close supply, return and exhaust dampers and seal duct openings in areas subject to construction dust.
2. Source Control
   a. How will reduction of contaminants be reduced at the source?
   b. What steps will be taken to employ low emitting products and sealants.
   c. How will air handling equipment be cycled off when not needed?
3. Pathway Interruption
   a. Describe how the construction space will be ventilated as required to dilute contaminants.
   b. Describe how occupied spaces adjacent to construction areas will be kept at positive pressure relative to spaces under construction.
4. Housekeeping: Describe how the following housekeeping objectives will be implemented:
   a. Reduction of dust generated by work will be suppressed.
   b. Maintaining a frequent cleaning frequency for dust and particulates.
   c. Remove spills or excess applications of solvent-containing products as soon as possible.
   d. Remove accumulated water and keep work areas as dry as possible.
   e. Protect insulation materials from exposure to moisture.
5. Scheduling: Describe how overlap of construction activity and ongoing building occupancy activities will be minimized.

F. Field Manual: Submit one copy of the SMACNA "HVAC Duct Construction Standards - Metal and Flexible". Maintain a second copy on the project site.

G. Any ductwork installed without prior approval by the specifier, shall be replaced at the expense of the contractor.

H. The contractor must comply with the enclosed specification in its entirety. If on inspections, the specifier finds changes have been made without prior approval, the contractor will make the applicable changes to comply with this specification, at the contractor's expense.

I. At the discretion of the specifier, sheet metal gauges and reinforcing may be checked at various times to verify all duct construction is compliant.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged components. Remove damaged products from project site.

1.7 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 DUCTWORK

A. Construct all ducts and plenum of gauges, and with joints, bracing, reinforcing, and other construction details in accordance with the latest construction standards previously listed. Metals shall be manufactured by United States Steel, Nucor or equal.

B. Duct dimensions indicated on drawings are net, inside, clear dimensions. For internally lined ducts, add lining thickness to determine metal duct dimensions.

C. Ducts shall be constructed of material gauges and reinforcement Class per SMACNA pressurization classifications to meet 150% of the pressure requirements for external static pressure scheduled on drawings for the fans serving each system. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the code or standard. Refer to Part III - Execution for matrix of pressure and leakage requirements.

D. Ductwork gauge shall not be thinner than 26-gauge for all work.

2.2 SHEET METAL MATERIALS

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

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
   1. Galvanized Coating Designation: G60 (Z180) for ductwork inside the building envelope in non-corrosive environments. G90 (Z275) for ductwork installed external to the building and may be installed inside the building as an alternate to G60.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

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

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

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 DUCTWORK FABRICATION

A. Rectangular Ducts
   1. Longitudinal Seams:
      a. Grooved seam flat/pipe lock (L-3), standing seam (L-4), single corner seam (L-5) or butt/corner weld for +/- 10 in. w.g. service. Snaplock and button-lock (L-1 and L-2) type joints are only allowed when ductwork is installed inside the conditioned space and when duct static pressures are less than 2” w.c. (500Pa).
   1. Lateral Joints:
      a. Slip drive joints, standard seams, flanges or welding as required by SMACNA HVAC Duct Construction Standards for system static pressure and sealed airtight. Flanged and gasketed joint fittings, such as Ductmate 25/35/45, Carlisle, MEZ Industries, or equal, are acceptable joint methods, but must be sealed as described previously. Transverse duct joints shall be constructed per Figure 1-4 for types T-8 through T-25. T-1 and T-5 slip joints are NOT allowed for transverse duct joints. T-5 slip joints may be used at connections to fire and smoke dampers as breakaway connections. Joint T-2, T-3, T-6 and T-7 reinforced slip joints are allowed below 2” static pressures.
      b. Exposed Ductwork: All sealant or gaskets applied internally within joint.
      c. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
      d. Welded where required for leakproof and airtight operation and per code.

B. Round Ducts
   2. Longitudinal Seams:
      a. Spiral seam (RL-1), butt weld (RL-4), or grooved seam flat/pipe lock (RL-5) for +/- 10 in. w.g. service.
   3. Lateral Joints:
      a. Exposed Ductwork: Beaded sleeve joint (RT-1), crimp joint bead (RT-5), or flange type joint. All joints secured with sheet metal screws. All sealant applied internally within joint.
      b. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
      c. Welded where required for leakproof and airtight operation.

C. Elbows
   1. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces, or as shown. For rectangular ductwork provide single thickness turning vanes on all short rectangular elbows less than 25" wide or provide double thickness turning vanes for short rectangular elbows 25" wide and greater. Number of vanes per SMACNA. Elbows with square throat and radius heel are NOT allowed.

D. Transitions
1. Construct transitions to not exceed the slopes identified per SMACNA HVAC Duct Construction Standards-Metal and Flexible. Slopes shall generally be no greater than 15%, and no greater than 30% where shown on the drawings.

E. Branch Connections
1. Provide 45°entry boots or radius taps for rectangular duct take-offs. Provide conical, bellmouth or 45° lo-loss boot taps for round duct take-offs. Straight 90° taps and spin-in taps are not allowed, except where round take-off duct size equals height of branch duct size. Provide volume dampers at each duct take-off for balancing. Provide insulation guards at transitions to lined ductwork.

F. Manufactured Joints
1. 316 stainless steel adjustable clamps with gaskets for connecting welded laterals, branches, and Y fittings. Manufacturer: CECO Environmental #KB Duct or equal.

2.4 RECTANGULAR DUCTWORK

A. Construct rectangular ductwork to meet all functional criteria defined in of the SMACNA HVAC Duct Construction Standards-Metal and Flexible. All ductwork must comply with all local, code requirements. Ductwork shall be constructed of galvanized steel. Diagonally cross break all panels on ducts 30 inches wide and larger, or bead using automatic bead machine with beads at 12 inches on center or less. All connections shall utilize 45° boot take-offs. Bullhead tees and straight taps are not permitted.
1. Listed manufactured ductwork system are allowed where they are installed per the manufacturer’s installation instructions and meet or exceed the requirements of the design requirements.

2.5 ROUND AND OVAL DUCTWORK

A. Round and oval ductwork shall be constructed to SMACNA round ductwork requirements of galvanized sheet steel. Comply with SMACNA HVAC Duct Construction Standards-Metal and Flexible, based on indicated static-pressure class unless otherwise indicated. Longitudinal seams shall be spiral lock seams or continuous welded. Flat oval may be utilized in space-restricted areas. All elbows shall be long radius type with centerline radius to duct diameter of 1.5, exceptions will only be allowed at restricted space locations.

B. Round or oval duct and fitting manufacturers:
1. McGill Airflow Corporation.
2. Lindab.
3. Semco.
4. Sheet Metal Connectors.
5. Spiral Manufacturing.
6. Nordfab.
7. Spiral Fittings.
8. Or equal.

C. Flat-Oval Ducts:
1. Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

D. Transverse Joints:
1. Fabricate according to SMACNA HVAC Duct Construction Standards-Metal and Flexible, for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions. All transverse joints, including mechanical flange type fittings, to be externally sealed at all joints.

2. Exception: internal manufactured single or dual EPDM rubber gasket fittings do not require external sealant.
3. Transverse joints in ducts larger than 50” diameter require flanged joints.
4. Lap or snap lock seams are not permitted for round ductwork of any size.

E. Longitudinal Seams:
1. Select seam types and fabricate according to SMACNA HVAC Duct Construction Standards - Metal and Flexible, Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA HVAC Duct Construction Standards-Metal and Flexible. All longitudinal joints shall be sealed air tight with sealant or continuous welding.
2. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
3. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals:
1. Select types and fabricate compliant with SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-5, "45 Degree Tees and Laterals”, and Figure 3-6, "Conical Tees” and “45 Degree Boot Tees" for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
2. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted.

G. Elbows:
1. Any deviation from a straight run shall be made using a gored or welded elbows or stamped elbows. Normal 90-degree elbows may include 5-gore fittings and the radius of the elbow is 1.5 times the diameter of the fabric duct. All gores shall be continuous metal or use fully welded joints/seams. Flexible or adjustable gore fittings are not allowed. Die stamped sheet metal elbows shall be fully welded on the heel and throat by an automated welder.
2. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces with prior approval or where shown on the drawings.

2.6 DIFFUSERS, GRILLES AND REGISTERS

A. All diffusers, grilles, and registers shall be selected to provide proper air distribution for the intended occupant application. All supply air devices shall be selected to provide a maximum air velocity of 50 fpm at three feet above the floor, unless otherwise noted. Manufacturer's representative shall carefully review Architectural and Mechanical drawings and ensure diffuser/grille/register selections will provide proper air distribution at NC 25 or less. Manufacturer at no additional expense to the Owner shall replace diffusers, grilles, and registers not providing proper distribution or excessive noise at scheduled airflow.

B. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper where individual duct mounted balancing dampers are not provided.

C. Refer to schedule on drawings for sizes, capacities and patterns.

D. Manufacturers: Titus, Krueger, Price, Metal Aire, Nailor, Anemostat, Carnes, Tuttle&Bailey, or equal.

2.7 DUCTWORK SEALANT

A. Duct tape, pressure sensitive type, is not allowed.

B. Solvent-based and oil-based sealants are not allowed indoors.

C. Seal all transverse joints, including mechanical joint flanges, similar to Ductmate, on all supply, return, exhaust, and outside air intake ducts.

D. All sealant systems for outdoor application to be suitable for use in exposure to water, sunlight, temperatures extremes associated with project location.

E. All sealant systems for indoor application to be meet VOC limits as specified in South Coast Air Quality Management District (SCAQMD) Rule #1168 limiting VOC's to 80 grams/liter for duct liner adhesives and 250 grams/liter for duct sealants.

F. Indoor Application Water-Based Joint and Seam Sealant:
   1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
      a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
      b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
      c. Flexibility on 1/4" mandrel.
      d. Freeze/thaw stability - 5 cycles.
      e. Service temperature: -20°F to +200°F (-29°F to +93°C).
      f. ASTM 5590; Resistance to mold, mildew and water.
      g. Meet all SMACNA seal classes.
      h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.
   2. Manufacturer: Carlisle (Hardcast) #Iron Grip 601 or #Flex-Grip 550 or #Spray-Seal, Ductmate #PROseal, Design Polymerics #DP1010 or #DP1020 or #DP 1010 Spray, or equal.

G. Indoor Application Water-Based Joint and Seam Sealant with Extended Material Warranty:
   1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
      a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
      b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
      c. Flexibility on 1/4" mandrel.
      d. Freeze/thaw stability - 5 cycles.
      e. Service temperature: -20°F to +200°F (-29°F to +93°C).
      f. ASTM 5590; Resistance to mold, mildew and water.
      g. Meet all SMACNA seal classes.
      h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.
      i. Manufacturer: Carlisle (Hardcast) #Iron Grip 601 or #Flex-Grip 550 or #Spray-Seal and #Aluma-Grip AFT-701 rolled sealant, or equal.
   2. And, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed by a 30-mil rolled sealant. Rolled sealant shall be comprised of a 2-mil foil faced with 28 mils of butyl adhesive/sealant conforming to the product specifications. Rolled sealant shall have the following physical properties:
      a. Peel Strength: 16 lbs. per linear inch.
      b. Tensile strength: 955 psi
      c. Elongation: 560%
      d. Bonding time: Instant with full bond in 24 hours.
      e. Resistance to mold, mildew and water.
      f. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
      g. Service temperature: -20°F to +200°F (-29°F to +93°C).
      h. Surface burning characteristics: Flame spread/smoke developed rating of 20/40, tested in accordance with UL 723.
      i. VOC: 0 g/l
      j. Meet all SMACNA seal classes.
      k. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, and 6" water gauge.
      l. Manufacturer: Carlisle (Hardcast) #Aluma-Grip AFT-701 rolled sealant, or equal.

H. Outdoor Application Two-Part Tape Sealing System:
   1. Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermally with tape to form hard, durable airtight seal.
   2. Manufacturer: Carlisle (Hardcast) #Two Part II, McGill Uni-Cast, or equal.

I. Outdoor Application Low VOC Solvent Based Joint and Seam Sealant:
   1. Flexible, adhesive sealant, suitable for outdoor application on joints and seams.
      a. Sealant shall be solvent based synthetic elastomeric. Water and UV resistant. Crack and peel resistant.
      b. Compliant with ASMT E84 and UL 723. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0 after cured.
      c. Freeze/thaw stability - 5 cycles.
      d. Service temperature: -20°F to +190°F (-29°F to +88°C).
      e. VOC: 44 g/l.
      f. ASTM 5590 compliant for resistance to mold, mildew and water.
      g. Meet all SMACNA seal classes.
      h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10” water gauge.
   2. Manufacturer: Design Polymerics #DP1090 or equal.

J. Rolled (Tape) Mastic Sealant for indoor and outdoor application on flat sheet metal duct joints. Aluminum substrate with modified butyl sealant. Compliant with UL 181B-FX. Rolled sealant shall have the following physical properties:
   a. Peel Strength: >10 lbs. per linear inch.
   b. Bonding time: Instant tack with full bond in 24 hours.
   c. Resistance to mold, mildew and water.
   d. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
   e. Service temperature: -20°F to +180°F (-29°F to +82°C).
   f. Surface burning characteristics: Flame spread/smoke developed rating of 5/25, tested in accordance with UL 723.
   g. VOC: 0 g/l.
   h. Meet all SMACNA seal classes.
   i. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6” and 10” water gauge.
   j. Roll width as required to maintain minimum 3/4” adhesion width on each side of joint.
   k. City of Los Angeles RR#8069 approved.
   l. Manufacturer: Carlisle (Hardcast) #Foil-Grip 1404-181BFX rolled sealant, or equal.

K. Manufacturers of duct sealant systems for various ductwork applications: Design Polymerics, Tremco, Dure Dyne, Carlisle Hardcast, Ductmate, Mon-Eco Industries, Sikaflex, and McGill AirSeal LLC.

2.8 FLEXIBLE DUCTWORK

A. Flexible one-inch thick (minimum) insulated round ductwork, Class 0 or Class 1, may be utilized for final connections to each air outlet and inlet, unless shown otherwise on the plans. Duct shall have a minimum R-4.2 for ductwork enclosed in conditioned spaces and R-8.0 for ductwork installed in unconditioned spaces. Maximum length of flexible ductwork in each low pressure branch shall not exceed five (5’) feet and maximum flexible connector lengths shall not exceed five (5’) feet.

B. All connections shall utilize welded conical tees, aluminum conical fitting, or manufacturer high efficiency branch take-offs. Spin-in type or other types of butt tees, bullhead tees or straight taps ARE NOT permitted. Manufacturers: Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO, or equal.

C. Dampers regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

D. Flexible ductwork for low pressure systems with positive static pressure up to 2” w.g. positive pressure and negative pressured up to 1/2" w.g. suitable for both terminal unit connection and

diffuser/grilles. Flexible ductwork fittings may be used at seismic expansion joints and to accommodate vertical drift between building levels. Fabrication shall include a multiple laminate of aluminized polyester/mylar, fiberglass insulation, and polyester, mechanically locked to galvanized steel helix without adhesives, exterior fiberglass insulation and fire retardant polyester/mylar outer jacket. Manufacturers: Casco #L-181M, Flexmaster #Type 5B, Thermaflex #M-KC or EverClean, or equal.

E. Flexible Duct Clamps: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes up to 18 inches to match duct size.

2.9 FABRIC DUCT SYSTEM

A. Air diffusers shall be constructed of a woven fire retardant fabric complying with the following physical characteristics:
   1. Fabric Construction: 100% Flame Retardant and treated with a machine wash-able anti-microbial agent from the manufacturer.
   2. Weight: 6.75 oz./yd^2 per ASTM D3776.
   3. Color: blue, white, tan, red, green, gray, black or custom color as approved by Owner's Representative.
   4. Air Permeability: 2 (+2/-1) cfm/ft^2 per ASTM D737, Frazier.
   5. Temperature Range: 0°F to 180°F.
   6. Fire Retardancy: Classified by Underwriters Laboratories in accordance with the flame spread/smoke developed requirements of NFPA 90-A and ICC AC167.
   7. Antimicrobial agent shall be proven 99% effective after 10 laundry cycles per AATCC Test Method 100.

B. Systems Fabrication Requirements:
   1. Air dispersion accomplished by linear vent and permeable fabric, linear vent to consist of many 3/16" diameter open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents.
   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 to 0.60 in. w.g. static pressure.
   7. End cap includes zipper for easy maintenance.
   8. Fabric system shall include connectors to accommodate suspension system listed below.
   9. Any deviation from a straight run shall be made using a gored or welded 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 fabric duct. All gores shall be continuous metal or fully welded joints/seams. Flexible or adjustable gore fittings are not allowed.

C. Design Parameters:
   1. Use fabric diffusers only for positive pressure air distribution components of the mechanical ventilation system.
   2. Do not use fabric diffusers in concealed locations.
   3. Fabric diffusers shall be designed from 0.25" water gage minimum to 3.0" maximum, with 0.5" as the standard.
   4. Fabric air diffusers shall be limited to design temperatures between 0°F and 180°F (-17.8°C and 82°C).
   5. Design CFM, static pressure and diffuser length shall be designed or approved by the manufacturer.

D. Suspension Hardware: (include applicable components only)
   1. Suspended H-Track: System shall include a single (1-Row) or double (2-Row) runs of aluminum H-Track system located 1.5" above top-dead-center (1 Row) or 1.5" above the 10 and 2 o'clock (2 Row) locations of fabric system. 2 Row supports are required for systems of 32" diameter and larger. Hardware to include 10' sections of track, splice connectors, track endcaps and vertical cable support kits – consisting of a length of cable with a locking stud end and Gripple quick cable connectors. Radius aluminum track must be included for all radius sections.
   2. Fabric / Track attachment
      a. Cord-In continuous supporting cord (not suggested for systems >24" Dia.).
      b. Snap-Tabs are a detachable sliding tab positioned every 24" along the length of the system (all diameters).
   3. Hardware components (optional)
      a. Provide 316 Stainless Steel components including coupler assembly, vertical cable support and Gripple quick cable connector.

E. Manufacturers: Fabric Air Dispersion Products, Ductsox, DurkeeSox, or approved equal.

2.10 PRE-INSULATED PHENOLIC FOAM DUCT SYSTEM FOR INDOOR CONDITIONED LOCATIONS

A. General
   1. Ductwork System materials, including the panel, adhesive, tape, sealant, flanges and gasket to be certified by Underwriters' Laboratory standard as a Class 1 air duct (UL 181)
   2. The preinsulated panels shall be manufactured of CFC-free phenolic foam thermo-bonded on both sides to a factory applied aluminum foil facing. The standard panel is to be no less than 1.15" (30mm) in thickness with minimum R-6 insulating value. Increase thickness as necessary to meet requirements of local energy code.
   3. All fabricated duct segments and fittings shall be designed to meet or exceed the minimum requirements of the "SMACNA HVAC Phenolic Duct Construction Standards" latest edition.
   4. Duct sizes are limited to maximum 80" x 80" operating up to 4" w.g. positive or 3" w.g. negative pressure class.

B. System
   1. The panels used in the fabrication of the ductwork system shall Pal Phenolic Duct rigid phenolic insulation panels with a thermal conductivity of 0.1977 BTU-in/hr•ft^2 °F and a minimum compressive strength of 29 psi, as manufactured by Pal International.
   2. Pal Phenolic Duct rigid phenolic insulation panels shall comprise a 3.4–3.75 pcf nominal density CFC/HCFC–free rigid Phenolic insulation core with zero Ozone Depletion Potential (ODP), autohesively bonded on both sides with 60-micron aluminum internal liner and a 200-micron aluminum external liner. Both liners are to be solid aluminum with no perforations.
   3. All other components required for the fabrication of the system shall be from the Pal Phenolic Duct System guidelines including the sealant, contact adhesive, aluminum tape, self–adhesive gasket, ductwork reinforcements, closures, connectors and flanges.

C. Fire and Smoke Performance
   1. The rigid phenolic insulation panels shall achieve the following fire and smoke performance requirements:
      a. ASTM E 84–low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
      b. UL 723 –low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
      c. UL 181 – UL/ULC classification as a Class 1 Air Duct to NFPA Standards 90A & 90B.

D. Sealant Material
   1. All internal seams must be fully sealed with an unbroken layer of Pal Phenolic sealant.

2. Each ductwork section must be duly connected with an inter-locking, double sealed jointing system. Sufficient sealant should be applied to each layer in order to seal the rigid phenolic insulation panels and ensure minimum air leakage.
3. Ductwork reinforcement, if necessary, shall be applied to protect against side deformation from both positive and negative pressure.
4. All external seams where two separate panels join must be tiger clipped, taped and jacketed in watershed fashion whenever possible to achieve a permanent bond with a smooth appearance.

E. Manufacturers: AQC Industries #PalDuct, KoolDuct or equal.

2.11 PRE-INSULATED DUCT SYSTEM FOR OUTDOOR AND UNCONDITIONED LOCATIONS

A. General
1. Pre-manufactured exterior ductwork to be a double layered duct system using the Pal Phenolic duct panels pre-fabricated and assembled into inter-locking sections. This as an alternate method to contractor fabricated double wall sheet metal ductwork with internal insulation.
2. All fabricated duct segments and fittings shall be designed in accordance with “SMACNA HVAC Phenolic Duct Construction Standards” latest edition.
3. Duct sizes are limited to maximum 80” x 80” operating up to 4” w.g. positive or 3” w.g. negative pressure class.

B. System
1. The panels used in the fabrication of the ductwork system shall Pal Phenolic Duct rigid phenolic insulation panels with a thermal conductivity of 0.1977 BTU-in/hr•ft^2 °F and a minimum compressive strength of 29 psi, as manufactured by Pal International.
2. Assembled panels shall be a minimum of 2” thick and minimum R-10 insulating value.
3. Pal Phenolic Duct rigid phenolic insulation panels shall comprise a 3.4–3.75 pcf nominal density CFC/HCFC–free rigid Phenolic insulation core with zero Ozone Depletion Potential (ODP), autohesively bonded on both sides with 60-micron aluminum internal liner and a 200-micron aluminum external liner. Both liners are to be solid aluminum with no perforations.
4. All other components required for the fabrication of the system shall be from the Pal Phenolic Duct System guidelines including the sealant, contact adhesive, aluminum tape, self–adhesive gasket, ductwork reinforcements, closures, connectors and flanges.
5. Exterior weatherproof cladding shall be a 5 ply, zero permeability vapor barrier, puncture resistant, tear resistant, flexible, and meet UL-1709.

C. Fire and Smoke Performance
1. The rigid phenolic insulation panels shall achieve the following fire and smoke performance requirements:
   a. ASTM E 84–low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
   b. UL 723 –low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
   c. UL 181 – UL/ULC classification as a Class 1 Air Duct to NFPA Standards 90A & 90B.

D. Sealant Material
1. All internal seams must be fully sealed with an unbroken layer of Pal Phenolic sealant.
2. Each ductwork section must be duly connected with an inter-locking, double sealed jointing system. Sufficient sealant should be applied to each layer in order to seal the rigid phenolic insulation panels and ensure minimum air leakage.
3. Ductwork reinforcement, if necessary, shall be applied to protect against side deformation from both positive and negative pressure.
4. All external seams where two separate panels join must be tiger clipped, taped and jacketed in watershed fashion whenever possible to achieve a permanent bond with weather protection and a smooth appearance.

E. Manufacturers: AQC Industries #QDuct, KoolDuct or equal.

2.12 FLUE VENTS AND STACKS

A. Refer to Section 235100 – Breechings, Chimneys, and Stacks for boiler flues and generator exhaust stacks.

2.13 FIBERGLASS DUCTBOARD

A. Ductboard shall be 1" thick (minimum) finished with a factory-applied thermosetting acrylic polymer coating to the air stream side resistant to potential dust incursion into the material substrate, containing an immobilized EPA-approved anti-microbial agent to further inhibit potential microbial growth as indicated by ASTM G-21 and G-22 test data and resistant to fiber shed and damage during duct cleaning operations.

B. Reinforce as necessary to assure no collapse of ducts under positive or negative pressures up to 1.0" w.g. of static pressure. Support ductwork with 3/4" wide galvanized sheet metal straps at intervals recommended by manufacturer. Protect duct wall against abrasion from support straps. Support at all fittings and each change in direction.

C. Product requirements:
1. Fiber glass duct board with a bio based thermosetting resin meeting.
2. Comply with ASTM C411, ASTM C1071, ASTM E84, UL723, and UL Greenguard Low VOC certified.
3. Comply with ASTM G21 and ASTM G22 and ASTM C1338 for microbial resistance.
4. K-value: 0.23 Btu•in./(hr•ft²•ºF) at 75°F (maximum).
5. Water vapor absorption: ASTM C1104, less than 3% by weight.
6. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.75 based on ASTM C423 Type “A” mounting.
7. Maximum allowable velocity on mat or coated air side: 1,000 ft./min.
8. Surface burning: NFPA 90 A and 90B.
9. Maximum operating temperature: 250°F.
10. Flame spread index: ASTM E84, less than 25.
11. Smoke developed index: ASTM E84, less than 50.
12. Density: 3.0 lbs./cu ft. (minimum).
13. Vapor Barrier Jacket: ASJ+ (All Service Jacket) or FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft paper.

D. Duct board must be fabricated and installed in accordance with the NAIMA or SMACNA Fibrous Glass Duct Construction Standards and all closure systems must meet the requirements of UL 181A.

E. Manufacturers: Johns Manville #Superduct RC, Certainteed #Ultra*Duct or equal.

2.14 PLENUMS AND EQUIPMENT CASINGS

A. Construct casings and plenums in conformance with SMACNA. Minimum Pressure Class: Unless otherwise indicated construct plenums and casings to withstand either a negative or positive static pressure of 4" w.g.

B. Single-Wall: Provide single-wall, casings and plenums where indicated on the drawings.
1. Construct in accordance with SMACNA Standards.
2. Use steel-angle-reinforced standing-seam construction.
3. Locate intermediate bracing angles bolted to the casing 24 inches on centers.
4. Construct for static pressure indicated or for the maximum fan static pressure whichever is less.

5. Bolt to 3" high concrete pads using 1-1/2" x 1-1/2" x 1/4" thick galvanized steel structural sections.

C. Double-Wall: Provide double-wall insulated ductwork where indicated on the drawings.
1. Construct in accordance with SMACNA Standards. Provide insulation thicknesses to meet or exceed the minimum required by local energy codes.
2. Provide 2" (minimum) thick prefabricated double wall insulated metal panel assemblies, with 16-gauge aluminum or 18-gauge minimum galvanized steel outer sheets.
3. Provide 22-gauge galvanized steel inner sheets to encapsulate the insulation.
4. Casings shall be fully metal enclosed, insulated with 2" thick (minimum) rigid fiberglass insulation and conforming to NFPA 90A, with maximum flame spread of 25 and maximum smoke developed of 50.
5. Field or factory fabricate to size and configuration indicated on the drawings, using field verified dimensions.
6. Provide coordinated shop drawings.
7. Reinforce spans 10' or greater with structural steel sections to yield maximum deflection 1/4" at minus 10" w.g. or plus 10" w.g. static pressure.
8. Provide openings and doors, all factory framed, and reinforced with 304 stainless steel structural sections.
9. Construct doors of same material as casings, of sizes and locations indicated on the drawings but not smaller than 18" by 54", and conforming to SMACNA.
10. Provide doors, hinges and hardware factory fabricated and mounted.
11. Door swings shall open against air pressure, with door latches operable from either side.
12. Provide door seals with neoprene gaskets, which have an airtight seal.
13. Provide each door with a 10" by 10" wire reinforced double pane window.
14. Bolt base channel to 3" high concrete pads.

2.15 DUCTWORK SPECIALTIES

A. General: Where specifically called for, materials for use in fabricating ductwork specialties shall be identical to that used to fabricate ductwork. See drawings and Part 3, Execution for schedule.

B. Flexible Connections (Indoor Applications):
1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame. Hypalon, teflon or silicone coated fabrics may be acceptable.
3. Shall be airtight, watertight and fire retardant.
4. Minimum density of 30 oz. per sq. yard.
5. Temperature range: -40°F to 200°F
6. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84.
7. Neoprene-only connectors are <u>not</u> allowed due to non-compliant surface-burning characteristics.
8. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal up to maximum dimensions of 4” metal, 6” fabric, 4” metal as required by application.
9. Manufacturers: Ventfabrics #Ventglas, Duro Dyne, Q Industries, Kinetics, Ductmate Proflex or Elgen.

C. Flexible Connections (Outdoor Applications):
1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Hypalon (chlorosulfurated polyethylene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.
3. Shall be airtight, watertight and fire retardant. Resistant to sunlight, ozone and weather.
4. Minimum density of 26 oz. per sq. yard.

5. Temperature range: -50°F to 275°F
6. Surface-Burning Characteristics: Non-combustible as tested per UL 701. Or, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84.
7. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal up to maximum dimensions of 4” metal, 6” fabric, 4” metal as required by application.
8. Provide flexible cloth insulating blanket to encase flexible connections to maintain ductwork insulation integrity as follows:
    1) Jacket shall be UV and ozone resistant with Velcro attachment.
    2) Service Operating Temperature: 0-350°F.
    3) Jacket and Liner: silicon or teflon impregnated fiberglass or mineral wool cloth.
    4) Insulation: Aerogel, 2” thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
    5) Fastening: 2” Nomex Velcro or 1” straps and stainless steel D-rings.
    6) Thread: Kevlar/stainless steel thread.
    7) Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, or equal.
9. Manufacturers: Ventfabrics #Ventlon, Duro Dyne, Kinetics, Ductmate Proflex or Elgen.

D. Volume and Splitter Dampers: Galvanized sheet metal blade and frame with Ventfabrics Inc., Ventlok operating hardware. For accessible dampers, provide #641 self -locking dial regulators and #644 self-locking dial regulators for insulated ductwork, #637 square end bearing, and #635 spring end bearing, as applicable. For inaccessible dampers, provide #666 or #677 concealed locking damper regulator with bearings as above. For static pressures above 3"wg, provide #640 HiVel dial regulator and #609 HiVel end bearing for accessible dampers. Regulators shall extend to and through ceiling with neatly installed hardware at the finished ceiling. For inaccessible dampers requiring adjustment through diffusers use Young Regulator, Bowden cable control system.

E. Multi-louver Volume Dampers: 16-gauge galvanized steel frame. Opposed, 6" wide, 16-gauge galvanized steel blades. Concealed linkage in frame. Ruskin #CD35/OBD or equal.

F. Ducts Through Roof: Unsupported duct penetration through a roof, without roof curbs, shall be 16-gauge (minimum), flashed and counterflashed, and provided with storm collars to secure a watertight construction.

G. Bird Screens: 19-gauge (0.91 mm) galvanized after weld wire mesh (minimum gauge), 1/2" x 1/2” openings (maximum) set in a galvanized steel frame. Or, 23-gauge (0.57 mm) galvanized after weld wire mesh (maximum gauge), 3/8" x 3/8” openings (minimum) set in a galvanized steel frame. Verify minimum requirements per local code.

H. Seismic Duct Connector (Indoors): Provide flexible connector at penetrations between two structural elements where the structural design has designated allowable seismic or settlement movement. Flexible EPDM elastomeric fabric bonded to a 1/4" steel perimeter flange on each end. EPDM shall be rated for maximum temperature of 250°F and 3 psi maximum. Connector shall be rated to meet or exceed structural design requirements with a minimum of 3” for axial compression, 3” axial extension, and 3” lateral deflection. Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84. Manufacturers: Mercer Rubber Co #ME-3/MI-9-3, Mason Industries #MD-4/MI-9, Flexicraft, Garlock, Hyspan, or equal.

I. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting rigid galvanized ductwork not exceeding 18” (450 mm) diameter, and suspended diffusers/grilles/terminal units. Alternate to metal strap options per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
    1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi

(1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.

2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher, or equal.

2.16 ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct." Access doors shall be insulated hollow core double construction. Access doors in exhaust ducts shall be of same, or heavier, gauge material as duct in which installed.

B. Casing Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 9-16, "Casing Access Doors." Access doors shall be insulated hollow core double construction of same, or heavier, gauge material as duct in which installed.

C. Minimum door size shall be 12" by 12" for simple manual access and up to 24" by 24" where personnel must pass through infrequently. Provide 20" x 54" (minimum) door for access to filters and more frequent maintenance.

D. Maximum door leakage shall not exceed 10 cfm/sq.ft. at maximum operating pressure. Doors larger than four sq.ft. in area shall open against pressure.

E. Doors:
1. Double wall, rectangular.
2. Galvanized sheet metal with insulation fill and gauge thickness as indicated for duct pressure class. Minimum 1” insulation thickness for doors up to 24” tall and 2” thick insulation for larger door assemblies as required per energy code. Insulation not required in exhaust duct access doors as allowed by local code.
3. Vision panel shall be provided on doors 24” x 60” and larger.
4. Fabricate doors airtight and suitable for duct pressure and air leakage class.
5. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets for doors up to 24” tall. For larger doors provide 1-1/2" by 1/8" flat stock or 14-gauge angle frame.
6. Gaskets: Closed cell neoprene rubber, 1” x 1/4" (minimum).
7. Access Door Manufacturers (Small Dimensions, Low Pressure Rating): CESCO, Pottorff, Ruskin, Vent Products, Air Balance, Ductmate Sandwich, United Enertech, or equal, as required by size and pressure application.

F. Hinges and Latches:
1. Access doors up to 14 by 14 inches (300 x 300 mm) square: Two hinges or continuous piano hinge and one sash lock. Doors shall not be removable.
2. Access doors up to 16 by 24 inches (400 by 600 mm) square: Two hinges or continuous piano hinge and two sash locks (minimum). Doors shall not be removable.
3. Access doors up to 24 by 48 inches (600 by 1200 mm): Three hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.
4. Access doors larger than 24 by 48 inches (600 by 1200 mm): Four hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.
5. Latch Manufacturer: Ventlok #100 Series hinges and latches on low pressure system doors up to 18 " maximum dimension, #200 Series on larger low pressure system doors, #333 Series on high pressure systems with stops, or equal.

2.17 CONTROL DAMPERS

A. General: Low leakage dampers shall be Class 1A with a maximum leakage rate of 3 cfm/ft^2 at 1.0 in wg pressure difference when tested to AMCA Standard 500.

B. Damper Type One: Airfoil Low Leakage Dampers (Galvanized Steel or Aluminum)
   1. Application: Commercial supply, return, and general exhaust air systems up to 3,000 fpm velocity. Damper shall be rated for -22°F to 122°F (-30°C to 50°C) minimum operating range.
   2. Frames to be 5" x 1"x 16-gauge galvanized steel hat-shaped channel or 5" x 1" x 0.125" anodized extruded aluminum hat channel with corner reinforcement.
   3. Blades: Airfoil shaped, single piece, 6" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum.
      a. Action:
         1) Parallel blade for open and closed control, and economizer dampers.
         2) Opposed blade for modulating and air flow measurement control.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
   6. Bearings: Self-lubricating stainless steel or molded synthetic sleeve.
   7. Linkage to be concealed in frame.
   8. Crank lever for operator to be provided.
   9. Provide with mill finish on blades and frame.
   10. Damper position indicator switch(es) as required by control sequence.
   11. Manufacturer: Ruskin #CD60 or #CD50, Swartout, NCA PBD/OPD-AF-101, American Warming, Tamco, Air Balance, Greenheck, Pottorff, Nailor or equal.

C. Damper Type Two: Airfoil Low Leakage for Coastal and High Moisture Environments (Aluminum)
   1. Application: Commercial supply, return, and general exhaust air systems where damper will be exposed to damp marine air and where velocity is less than 3,000 fpm. Damper shall be rated for -22°F to 122°F (-30°C to 50°C) minimum operating range.
   2. Frame to be 5" x 1" x 0.125 anodized extruded aluminum hat channel with silicon side seals and corner reinforcement.
   3. Blades: Airfoil shaped, single piece, 6" wide (maximum), 6063-T5 anodized aluminum.
      a. Action:
         1) Parallel blade for open and closed control, and economizer dampers.
         2) Opposed blade for modulating and air flow measurement control.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 1/2" diameter steel, hex-shaped, mechanically attached to blade.
   6. Bearings: Self-lubricating stainless steel sleeve or molded synthetic sleeve.
   7. Linkage to be concealed in frame.
   8. Stainless steel hardware.
   9. Damper position indicator switch(es) as required by control sequence.
   10. Manufacturer: Tamco #SW Series, Ruskin #CD50, Swartout, NCA, Pottorff, American Warming, Air Balance, Greenheck or equal.

D. Damper Type Three: Heavy Duty Fan Discharge Control
   1. Application: Velocity over 3,000 fpm as fan outlet damper.
   2. Frames to be 8" x 2" x 12-gauge steel channel (minimum).
   3. Blades to be 8" wide (maximum), 0.080 thick extruded aluminum airfoil design.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 3/4" diameter steel, hex-shaped, mechanically attached to blade.
   6. Bearings: Stainless steel sleeve type pressed into frame.
   7. Linkage to be out of airstream with 10-gauge galvanized steel clevis type arms with crank lever operator.
   8. Provide with mill finish on blades and frame.
   9. Maximum temperature rating to be 300°F.

10. Manufacturer: Ruskin #CD102, Nailor, Swartout, Pottorff, American Warming, Air Balance, Greenheck or equal.

E. Damper Type Four: Low Leakage Airfoil Insulated Dampers
1. Application: Air handler intake and exhaust. Damper shall be rated for -25°F to 180°F (32°C to 83°C) minimum operating range.
2. Frames to be 5" x 1"x 16-gauge galvanized steel hat-shaped channel or 5" x 1" x 0.125" anodized extruded aluminum hat channel with corner reinforcement.
3. Blades: Insulated, single piece, 6" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum, R-3.3.
   a. Action: Parallel blade for open and closed control.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel or molded synthetic sleeve.
7. Linkage to be concealed in frame.
8. Crank lever for operator to be provided.
9. Provide with mill finish on blades and frame.
10. Damper position indicator switch(es) as required by control sequence.
11. Manufacturer: Ruskin #IL35, Greenheck, Pottorff, Tamco, or equal.

F. Damper Type Five: Ultra Low Leakage Airfoil, Double Row Dampers
1. Application: Natural ventilation wall inlets and outlets with parallel (double row) damper blades. Damper shall be rated for -72°F to 275°F (-58°C to 135°C) minimum operating range.
2. Frames to be 8" x 1" steel or aluminum channel thermally broken with insulation within frame channels.
3. Blades: Airfoil shaped, single piece, 4" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum.
   a. Action: Parallel blade for open and closed control.
4. Seals: Silicone rubber or EPDM blade and jam seals.
5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
6. Bearings: Self-lubricating stainless steel or molded synthetic sleeve.
7. Linkage to be concealed in frame
8. Crank lever for operator to be provided.
9. Provide with mill finish on blades and frame.
10. Damper position indicator switch(es) as required by control sequence.
11. Manufacturer: Ruskin #CD40x2, Greenheck, Pottorff, Tamco, or equal.

2.18 BACKDRAFT AND RELIEF DAMPERS

A. Light Duty Counterbalanced Backdraft Damper
1. Applications: Low pressure ductwork systems, including outside air intake and exhaust locations.
2. Frame: Extruded aluminum channel frame with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.025" (0.6 mm) minimum formed aluminum. Maximum 6" wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable steel weights mechanically attached to blade.
5. Mounting: Vertically or horizontally oriented as shown on the drawings.
6. Sized for maximum velocity of 1,500 fpm (7.6 m/s).
7. Maximum back pressure of 2.0" w.g. (1.1 kPa).
8. Maximum Pressure Drop Fully Open: 0.06" w.g. (15 Pa).
9. Manufacturer: Ruskin #CBD2, Greenheck #WD Series, or equal.

B. Heavy Duty Counterbalanced Backdraft Damper
1. Application: Medium pressure air ductwork and generator exhaust.
2. Frame: Galvanized steel, 16-gauge (1.5 mm) wall thickness minimum with flanges to match ductwork requirements.

3. Blades: Parallel blades, horizontal orientation, 0.05” (1.2 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable steel weights mechanically attached to blade.
5. Mounting: Vertically or horizontally oriented as shown on the drawings.
6. Sized for maximum velocity of 2,500 fpm (12.7 m/s).
7. Maximum back pressure of 4.5” w.g. (1.1 kPa).
8. Maximum Pressure Drop Fully Open: 0.20” w.g. (50 Pa).
9. Manufacturer: Ruskin #BD6, Greenheck #HB Series, Nailor #1380, or equal.

C. Barometric Relief Damper
1. Applications: Gravity hood exhaust, room pressurization control and stairwell pressurization relief.
2. Frame: Extruded aluminum channel frame, 0.090” (2.3 mm) wall thickness minimum with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.063” (1.6 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable on-blade counterweights for tuning of start-to-open and full open blade operation.
5. Axle: 3/8” (9.5 mm) galvanized steel rod with roller bearings.
6. Mounting: Vertically or horizontally oriented as shown on the drawings.
7. Sized for maximum velocity of 1,000 fpm (5.1 m/s).
8. Maximum back pressure of 2.0” w.g. (0.5 kPa).
9. Start-Open Pressure: 0.05” w.g. (12.5 Pa).
10. Manufacturer: Greenheck #BR-30 for vertical mounting, Greenheck #BD-10 for horizontal mounting, or equal.

D. Round Counterbalanced Backdraft Damper
1. Dampers shall be of the two-blade design with separate axles. Blades shall be retained in closed position with tensioned spring and field adjustable for required opening pressure. Not allowed for installation in dryer exhaust, kitchen exhaust or bypass air applications.
2. Frame: 20-gauge (1.0 mm) minimum galvanized steel.
3. Blade: 0.016” thick (0.40 mm) minimum aluminum.
4. Blade Seals: Vinyl foam.
5. Axle: 3/16” (4.8 mm) minimum steel.
6. Maximum Velocity: 1,000 fpm (7.6 m/s).
7. Maximum Pressure Drop Fully Open: 0.06” w.g. (125 kPA).
8. Manufacturer: Ruskin #BDR2, Greenheck #WDR-53 or equal.

E. Light Duty Non-Counterbalanced Neoprene Backdraft Damper
1. Applications: Low pressure exhaust from small mechanical equipment less than 2,500 cfm.
2. Frame: 16-gauge galvanized steel with flanges to match ductwork requirements.
3. Blades: Neoprene coated fiberglass. Maximum 6” wide blades.
4. Mounting: Vertically or horizontally oriented as shown on the drawings.
5. Sized for maximum velocity of 1,000 fpm (5.1 m/s).
6. Manufacturer: Ruskin #NMW2 or equal.

2.19 LOUVERS

A. Louvers are generally to be provided under Division 8 or as specified in the equipment schedules on the drawings. Where louvers are not covered on architectural plans and specifications, contractor is to provide louvers with the following minimum specifications:
1. Louvers to be 6" deep, 35° drainable fixed blade design, constructed of galvanized steel or extruded aluminum, or as specified on the plans.
2. Frames to be constructed of 6" deep channel, aluminum or galvanized steel.
3. Provide with 1/2" x 1/2" aluminum mesh bird screen mounted on backside of louver.

4. Finish/color per architect/engineer's review of manufacturers color chart or custom color matching if required.
5. Manufacturer: Ruskin #ELF6375DX or equal.

2.20 DUCT SMOKE DETECTORS (DSD)

A. Duct mounted photoelectric smoke detector. One required for each heating or cooling system supplying air in excess of 2,000 cfm, for systems serving more than one occupancy type, and for control of each combination fire/smoke damper when not controlled by Division 26 area wide detection system.

B. Coordinate with Division 26 work and electrical installer for power to smoke detector. Detector shall be installed in the system in compliance with Chapter 6 of the Mechanical Code and NFPA-72. Provide 24-volt power supply option and/or 24-volt transformer as required to coordinate with Division 26.

C. Coordinate with control installer to assure that detector shall shut down the air-moving equipment when smoke is detected and close associated damper actuator(s). Sensor shall be selected to operate with air velocity rating from 100 to 4000 fpm. Provide with metal sampling tube. Provide remote test and reset station at ceiling or as otherwise indicated. Duct smoke detector shall be installed in the supply or return in compliance with the applicable mechanical or building code. Coordinate with Section 230900 and 230593 work.

D. Provide additional duct smoke detectors per requirements of Section 6.4 of NFPA-90A. Provide one duct smoke detector at each story to the connection to a common supply and/or return and prior to any recirculation or fresh air inlet connection in air return systems having a capacity greater than 15,000 cfm and serving more than one story.

E. Provide additional duct smoke detectors in high rise buildings and I-2 Occupancies per the Section 907.2 of the Building Code with duct smoke detectors in the main return and exhaust air plenums of each air-conditioning system having a capacity greater than 2,000 cfm.

F. Manufacturer: System Sensor #D2 series or equal.

2.21 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPERS

A. General:
1. Provide UL labeled 3 hour rated fire dampers at 3-hour and greater penetrations.
2. Provide UL labeled 1-1/2 hour rated fire dampers at less than 3-hour penetrations.
3. All dampers to be certified under the latest UL Standard. Certification based on former non-current standards is unacceptable.
4. All damper installations to conform with NFPA 90A and manufacturer's installation instructions. Details on drawings are shown for reference only.
5. Install in ducts passing through walls, floors, and ceilings as required by code. Refer to Architectural and Mechanical plans for damper locations.
6. Provide fire, smoke and fire/smoke dampers in locations as required by local code and NFPA-90A and 92A.
7. Provide sleeves, slip joints, retaining angles, duct access doors, ceiling access panels, etc., as required to check and service the fire dampers. Slip or break away joints are not allowed to be taped or sealed.
8. Access doors shall be tight fitting hinged with operable cam latches. Removable doors are not allowed. Access shall not require the use of keys, tools or special knowledge. The access point shall permanently labeled with 1” (25 mm) high letters: "FIRE DAMPER”, “SMOKE DAMPER”, or “FIRE/SMOKE DAMPER”.
9. All dampers to be designed for use in dynamic systems.
10. Dampers shall be rated for Leakage Class I. Leakage Class II may be used if damper size is smaller than available Leakage Class I dampers.

11. Dampers shall be certified for use by State and local authorities.
12. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress doe to twisting, racking, bowing, or other installation error. Do not install actuators in area where moisture can penetrate actuator or where temperature exceeds 120°F.
13. All fire dampers shall be sized to provide equivalent free area through the damper equal to, or greater than, the free area of the connecting ductwork. Upsize fire dampers as required to minimize pressure drops. In no case is the damper pressure drop to exceed 0.20" w.g., but ideally less than 0.10" w.g .for low velocity dampers, as designed for total system static pressure allowance. Refer to submittal requirements in Part One of this section and requirements on the drawings.

B. Radiation Ceiling Fire Dampers:
1. Bladed ceiling fire damper constructed and tested in conformance with UL-555C (dynamic rating).
2. Fire damper shall have a fusible link that opens at 165°F (74°C) or 212°F (100°C) for high temperature duct applications. Installation shall be in accordance with damper manufacturer's instructions.
3. Provide fire blanket where required to obtain listed fire rating.
4. Manufacturers: Ruskin #CFD Series, Greenheck #CRD Series, or equal by Pottorff, Cesco, Nailor, or Air Balance.

C. Dynamic Fire Dampers (FD) for use in Dynamic and Static Systems:
1. Curtain fire damper constructed and tested in conformance with UL-555C.
2. Fire damper shall have a fusible link that opens at 165°F (74°C) or 212°F (100°C) for high temperature duct applications. Fire damper shall be equipped for vertical penetrations with manufacturer supplied sleeve. Installation shall be in accordance with damper manufacturer's instructions.
3. Curtain damper shall not be located in air stream during system operation, Style B or C. Clear inside opening through fire damper is to match clear inside opening of duct. Fire dampers in lined ducts are to match size of sheet metal duct.
4. Dynamic Closure Rating Velocity: 2000 fpm (minimum).
5. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10" w.g. at full air flow.
6. Pressure rating: 4" w.g.
7. Manufacturers: Ruskin #DIBD Series, Greenheck #DFD Series, or equal by Pottorff, Air Balance, Nailor or CESCO.

D. Combination Fire and Smoke Dampers (FSD):
1. Required Locations:
   a. Install at ducted penetrations through rated fire barriers, fire walls, rated ceilings, rated corridor ceilings, shaft enclosures, and smoke barriers and partitions as defined on Architectural drawings and Chapter 7 of the Building Code.
   b. Per NFPA-90A install smoke dampers or combination fire/smoke dampers in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment from the remainder of the system on the building supply and return side. Air handling units located on the floor they serve and only serving that floor are exempt. Air handling units located on the roof and serving only the floor immediately below the roof shall be exempt.
2. General Requirements:
   a. Dampers shall be Low Leakage Class 1 in accordance with UL 555S.
   b. Dampers shall be provided as a manufactured UL listed device with electric actuator. Actuator shall be attached to sleeve outside of air stream.
   c. Temperature Rating: 165°F (74°C) or 212°F (100°C) for high temperature duct applications.

d. Mounting: Vertical or horizontal
e. Frame: 5” wide by 16-gauge roll formed, galvanized steel hat-channel, minimum.
f. Sleeve: Minimum 20-gauge thickness and minimum 16” long.
g. Bearings: Stainless steel, permanently lubricated sleeve type.
h. Each damper shall be equipped with a controlled 15 second electric heat-actuated release device. This device is to be equipped with a push-button reset. No manual fusible links are permitted. Installation shall be in accordance with damper manufacturer's instructions. Coordinate power and smoke detector connections with electrical installer. Integral smoke detection and actuating devices may be used if listed and approved for such service. Comply with building code requirements. All combination fire and smoke dampers shall automatically reset from closed to open position upon the reapplication of power to actuators, if temperature switch is not tripped.
i. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
j. Voltage: Coordinate with Division 26 work and electrical installer for power to damper actuator. Provide 24 VAC, 120 VAC or 230 VAC power option to match power supply provided by Division 26. Prior to purchase and installation coordinate with Division 26 to align power requirements at no additional cost to Owner.
k. Electric Actuators: All gear and housing shall be steel. The actuator shall be direct coupled and employ a steel toothed cold-weld clamp for connecting to damper shafts. Aluminum clamps or set-screw attachments are not acceptable. Actuator shall be UL listed and manufactured under ISO 9001 quality control.
    1) Actuator shall carry a manufacturer’s 5-year warranty.
    2) Damper position shall fail closed on loss of power.
    3) Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible. Actuator shall be incapable of burning out if stalled before full rotation is reached.
    4) Actuator shall have UL555S Listing by the damper manufacturer and be rated for 20,000 cycles minimum. Actuator shall draw no more than 0.23 amps at 120-volt running, or 0.11 amps holding at 120-volt (27 VA and 10 VA respectively for 24-volt power) for 70 in.lbs. torque.
    5) Stall and instantaneous type actuators are not acceptable.
    6) Do not install in areas where moisture can penetrate damper or actuator, nor where actuator temperature exceeds 122°F (50°C).
    7) Manufacturer: Belimo #FS Series or equal by Siemens, Johnson Controls, or Honeywell.

3. Required Options:
    a. Provide open or closed indicator assembly consisting of a single pole, double throw switch used to indicate damper blade position. Include switch mounting bracket, crank arm, blade bracket and linkage from blade to the switch. Or, provide optional actuator end switches to indicate damper open and damper closed positions. Coordinate with fire alarm system and FireFighter’s Smoke Control Panel for remote indication and damper override control.
    b. Provide a damper mounted testing module to permit test cycling of the damper actuator assembly as required for start-up testing and maintenance.
    c. Provide integral duct smoke detector and coordinate with Division 26 for area smoke detection and comply with NFPA-90A and NFPA-72. All wiring to be provided by Division 26 installers. In buildings not equipped with an approved fire alarm system the smoke detection activation shall cause a visual signal and audible signal in a normally occupied area and be identified as air duct detector trouble.For exposed wall applications provide matching wall grille to maintain appearance and fire rating.

e. Temperature limited override: Provide a two-temperature electronic high temperature limit. A primary sensor at 165°F (or higher temperature as dictated by AHJ or Building Code) can be bypassed by an external electrical signal allowing the damper to reopen and remain open until the temperature reaches the setting of the secondary sensor at 350°F at which point the damper is closed and remains closed. Both sensors are to be equipped with manual resets.

4. Low Velocity Applications (1500 fpm or below):
   a. Maximum Rate Velocity: 1500 fpm.
   b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturers: Ruskin #FSD37 or #FSD60 or #FSD60-3, Ruskin #FSDR25 or #FSDR60 round style, Greenheck #FSD-211 or #FSD-231 or #FSD-311 or #FSD-311M, or equal by Pottorff, Nailor, Cesco or Air Balance.
5. High Velocity Applications (Greater than 1500 fpm):
   a. Maximum Rate Velocity: 4000 fpm.
   b. Style: True airfoil-shaped, extruded aluminum blades with silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.20” w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturers: Ruskin #FSD60 or #FSD60-3, Greenheck #FSD-211 or #FSD-231 or #FSD-311 or #FSD-331, or equal by Pottorff, Nailor, Cesco or Air Balance.
6. Low and Medium Velocity Round Applications (3000 fpm or below):
   a. Maximum Rate Velocity: 3000 fpm.
   b. Style: Two piece 14-gauge thickness galvanized steel with mechanically fastened silicone edge seals
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.15” w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturers: Ruskin #FSDR25 or #FSDR60, Greenheck #FSDR-511, or equal by Pottorff, Nailor, Cesco or Air Balance.
7. Corridor Ceiling Application:
   a. Maximum Rate Velocity: 1500 fpm.
   b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” sp w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturers: Ruskin #FSD60-C, Greenheck #CFSD-211, or equal by Pottorff, Nailor, Cesco or Air Balance.

E. Smoke Dampers (SD):
1. Required Locations:
   a. Install at rated smoke barriers and partitions as defined on Architectural drawings and Chapter 7 of the Building Code.
   b. Per NFPA-90A install smoke dampers in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment from the remainder of the system on the building supply and return side. Air handling units located on the floor they serve and only serving that floor are exempt. Air handling units located on the roof and serving only the floor immediately below the roof shall be exempt.
2. General Requirements:
   a. Dampers shall be Low Leakage Class 1 in accordance with UL 555S.

b. Dampers shall be provided as a manufactured UL listed device with electric actuator. Actuator shall be attached to sleeve outside of air stream.
c. Temperature Rating: 165°F (74°C) or 212°F (100°C) for high temperature duct applications.
d. Mounting: Vertical or horizontal
e. Frame: 5” wide by 16-gauge roll formed, galvanized steel hat-channel, minimum.
f. Sleeve: Minimum 20-gauge thickness and minimum 12” long.
g. Bearings: Stainless steel, permanently lubricated sleeve type.
h. Smoke damper shall be equipped for vertical wall penetrations with manufacturer supplied sleeve and fail closed on loss of power. Each damper shall be equipped with a controlled 15 second electric heat-actuated release device. This device is to be equipped with a push-button reset. No manual fusible links are permitted. Installation shall be in accordance with damper manufacturer's instructions. Coordinate power and smoke detector connections with electrical installer. Integral smoke detection and actuating devices may be used if listed and approved for such service. Comply with building code requirements. All combination smoke and fire dampers shall automatically reset from closed to open position upon the reapplication of power to actuators, if temperature switch is not tripped.
i. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
j. Voltage: Coordinate with Division 26 work and electrical installer for power to damper actuator. Provide 24 VAC, 120 VAC or 230 VAC power option to match power supply provided by Division 26. Prior to purchase and installation coordinate with Division 26 to align power requirements at no additional cost to Owner.
k. Electric Actuators: All gear and housing shall be steel. The actuator shall be direct coupled and employ a steel toothed cold-weld clamp for connecting to damper shafts. Aluminum clamps or set-screw attachments are not acceptable. Actuator shall be UL listed and manufactured under ISO 9001 quality control.
    1) Actuator shall carry a manufacturer’s 5-year warranty.
    2) Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible. Actuator shall be incapable of burning out if stalled before full rotation is reached.
    3) Actuator shall have UL555S Listing by the damper manufacturer and be rated for 20,000 cycles minimum. Actuator shall draw no more than 0.23 amps at 120-volt running, or 0.11 amps holding at 120-volt (27 VA and 10 VA respectively for 24-volt power) for 70 in-lb torque.
    4) Stall and instantaneous type actuators are not acceptable.
    5) Do not install in areas where moisture can penetrate damper or actuator nor where actuator temperature exceeds 122□F (50°C).
    6) Manufacturer: Belimo #FS Series or equal by Siemens, Johnson Controls, or Honeywell.

3. Required Options:
    a. Provide open or closed indicator option assembly consisting of a single pole and a double throw switch used to indicate damper blade position. Output from switch to position indicator light (LED, provided by Division 26) is by automatic temperature control contractor. Include switch mounting bracket, crank arm, blade bracket and linkage from blade to the switch.
    b. Provide a test module to permit test cycling of the damper/actuator in the field
    c. Provide integral duct smoke detector or coordinate with Division 26 for area smoke detection. Division 26 to provide all wiring.For exposed wall applications provide matching wall grille to maintain appearance and fire rating.
4. Low Velocity Applications (1500 fpm or below):
    a. Maximum Rate Velocity: 1500 fpm.

b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” sp w.g. at full air flow.
d. Pressure rating: 4” w.g.
e. Manufacturer: Ruskin #SD-37, Ruskin #SD-60, Greenheck #SMD-201, Pottorff #SD-141, Pottorff #SD-151, or equal by Nailor, Cesco or Air Balance.

5. High Velocity Applications (Greater than 1500 fpm):
a. Maximum Rate Velocity: 4000 fpm.
b. Style: True airfoil-shaped, extruded aluminum blades with silicone edge seals.
c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.20” sp wg at full air flow.
d. Pressure rating: 4” wg.
e. Manufacturer: Ruskin #SD-50, Greenheck #SMD-401, or equal by Pottorff, Nailor, Cesco or Air Balance.

2.22 VARIABLE AIR VOLUME TERMINAL UNITS

A. Furnish and install variable volume zone boxes of the sizes and capacities shown on the Drawings.

B. The control assemblies shall be pressure independent and shall be able to be reset to any airflow between zero and maximum scheduled CFM. The valves shall be normally open. The differential static pressure of the basic assembly shall not exceed 0.25" w.g. for all sizes with inlet velocities of 2,000 fpm or less.

C. The air valve shall be galvanized steel or die cast aluminum; damper shafts shall operate in rustproof Delrin or equal, self-lubricating bearings. The air valve shall seat against durable gaskets and not exceed a 2% leakage rate per ARI standards.

D. The control device shall be designed to maintain consistent flow measurement regardless of inlet flow deflection. Angled duct inlets, at 90° or less to the control device, shall not alter the maximum or minimum factory setting by more than 10%. The assembly shall incorporate a multi-point averaging differential pressure sensor mounted on the inlet.

E. The cabinet assemblies shall be contained in a 22-gauge (minimum) galvanized steel box.

F. Cabinet shall be internally insulated with liner that prevents fibers from entering the air stream.
1. Insulation liner shall be 3/4" thick (minimum) or greater. Refer to schedule on drawing for additional requirements that may be more restrictive.
2. Insulation types include, but are not limited to, the following:
a. Fiberglass or mineral wool acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
b. Fiberglass or mineral wool insulation with a foil or sheetmetal facing.
c. Elastomeric or polyimide foam insulation with acrylic polymer airstream coating.
d. Natural (denim or recycled) fiber with bio based thermosetting resin mat fiber-free facing, foil facing or sheetmetal facing.
3. Refer to Section 230713 “Duct Insulation” for additional requirements.
4. Comply with ASTM E84, ASTM C1071, UL 723, UL 181, NFPA 90A and 90B, and UL Greenguard Low VOC certified.
5. K-value: 0.25 Btu•in./(hr•ft²•°F) at 75°F (maximum).
6. Flame spread index: ASTM E84, less than 25.
7. Smoke developed index: ASTM E84, less than 50.

G. Fabricate and install 5 foot (minimum) acoustically lined sheet metal discharge plenum on all air terminal units. Refer to detail on drawings for more information. Discharge plenum shall be mounted downstream of reheat coils where applicable. Inside dimension of plenum shall be 2" larger in height

and 4” larger in width than the outlet of the air terminal unit or reheat coil, whichever is greater. Refer to detail on plans for additional information. This is required for acoustic noise dissipation.

H. Hot Water Coil: Where scheduled on drawings, provide a single or double row hot water heating coil with aluminum fins mechanically bonded to copper coils. Coil velocity shall not exceed 700 FPM and static pressure loss shall not exceed 0.35" w.g. for a double row coil or 0.20” w.g. for a single row coil. Coil shall be pressure tested to 200 PSIG. Maximum water pressure drop shall be limited to 5 feet w.g. unless otherwise noted.

I. Electric Coil: Terminal manufacturer to factory install coil. Coil to be UL listed. They shall be housed in an attenuator section integral with the terminal with element grid recessed from unit discharge a minimum of 5" to prevent damage to elements during shipping. Elements shall be derated nickel chrome, supported by ceramic isolators a maximum of 3.5" apart, staggered for maximum thermal transfer and element life and balanced to ensure equal output per step. The integral control panel shall be housed in a NEMA 1 enclosure with hinged access door for access to all controls and safety device. Provide a primary automatic reset thermal cutout, a manual reset secondary thermal cutout, line fusing, mercury contactors per element, differential pressure airflow switch for proof of flow, and line terminal block. Coil shall be capable of operating under continuous duty at 120°F discharge temperature. Unit shall include an integral door interlock type disconnect switch which will not allow the access door to be opened while power is on. Coils 4 kw to 8 kw shall be 2 stage, 8 kw and larger shall be 3-stage. Coordinate final voltages with Div. 26.

J. Controls to be direct digital and connected to the BAS. Provide boxes without operator. Provide factory mounted low voltage transformer of sufficient capacity to power the DDC controls. Coordinate control with temperature Control Contractor. Provide factory mounted operator and thermostat control if not provided by Control Contractor.

K. Manufacturer: Titus ESV-3000, Price SDV, Trane VC, Enviro-Tec SSD, Carnes AV, Tuttle & Bailey SDV, Nailor 3000, Krueger, Anemostat, or equal.

2.23 FAN POWERED BOXES

A. Furnish and install fan powered boxes of the type, sizes and capacities shown on the Drawings.

B. Casing: 22-gauge galvanized steel casing with rectangular discharge with slip and drive type connection. One-piece aluminum backdraft damper provided on fan discharge. Damper factory set and aligned for precise seal. Leak rate 2% at 0.5 w.g.

C. Cabinet shall be internally insulated with liner that prevents fibers from entering the air stream.
   1. Insulation liner shall be 3/4" thick (minimum) or greater. Refer to schedule on drawing for additional requirements that may be more restrictive.
   2. Insulation types include, but are not limited to, the following:
      a. Fiberglass or mineral wool acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
      b. Fiberglass or mineral wool insulation with a foil or sheetmetal facing.
      c. Elastomeric or polyimide foam insulation with acrylic polymer airstream coating.
      d. Natural (denim or recycled) fiber with bio based thermosetting resin mat fiber-free facing, foil facing or sheetmetal facing.
   3. Refer to Section 230713 “Duct Insulation” for additional requirements.
   4. Comply with ASTM E84, ASTM C1071, UL 723, UL 181, NFPA 90A and 90B, and UL Greenguard Low VOC certified.
   5. K-value: 0.25 Btu•in./(hr•ft²•°F) at 75°F (maximum).
   6. Flame spread index: ASTM E84, less than 25.
   7. Smoke developed index: ASTM E84, less than 50.

D. The control device shall be designed to maintain consistent flow measurement regardless of inlet flow deflection. Angled duct inlets, at 90° or less to the control device, shall not alter the maximum

or minimum factory setting by more than 10%. The assembly shall incorporate a multi-point averaging differential pressure sensor mounted on the inlet.

E. Air Valve: Galvanized steel or cylindrical die cast aluminum airflow control device. Valve tapered to fit standard round flexible duct diameters. Normally open sequencing for reverse acting thermostat. Leak rate 4% at 2" w.g. Integral flow ring taps, calibration chart for flow measurement, ±10% accuracy regardless of inlet condition.

F. Fan: Fan style galvanized steel wheel. Housing is 18-gauge steel and fan board is 16-gauge steel.

G. Motor to be an Electrically Commutated Motor (ECM) with a minimum efficiency of 70% throughout the operating range. Motor speed to be controlled for a constant delivery fan cfm regardless of varying external static pressure. Provide remote adjustment option for integration with DDC controls by others.

H. Fan Controls: Factory mounted on-off toggle switch, for disconnect and normally open P.O. switch to energize fan.

I. Disconnect Switch: Provide factory mounted fused disconnect switch with interlocking door handle on terminal box door.

J. Dust Cover: Integral control panel shall be gasketed for tight seal.

K. Hot Water Coil: Where scheduled on drawings, provide a single or double row hot water heating coil with aluminum fins mechanically bonded to copper coils. Coil velocity shall not exceed 700 FPM and static pressure loss shall not exceed 0.35" w.g. for a double row coil or 0.20" w.g. for a single row coil. Coil shall be pressure tested to 200 psig.

L. Electric Coil: Terminal manufacturer to factory install coil. Coil to be UL listed. They shall be housed in an attenuator section integral with the terminal with element grid recessed from unit discharge a minimum of 5" to prevent damage to elements during shipping. Elements shall be derated nickel chrome, supported by ceramic isolators a maximum of 3.5" apart, staggered for maximum thermal transfer and element life and balanced to ensure equal output per step. The integral control panel shall be housed in a NEMA 1 enclosure with hinged access door for access to all controls and safety device. Provide a primary automatic reset thermal cutout, a manual reset secondary thermal cutout, line fusing, mercury contactors per element, differential pressure airflow switch for proof of flow, and line terminal block. Unit shall include an integral door interlock type disconnect switch which will not allow the access door to be opened while power is on. Coils 4 kw to 8 kw shall be 2-stage, 8 kw and larger shall be 3-stage. Coordinate final voltages with Div. 26.

M. VAV Control: Factory mounted and piped to pneumatic or electronic actuator. Regulator is thermostatically reset with velocity controller, which provides constant delivery air control within ±10% accuracy regardless of inlet condition. The velocity signal is input to the volume regulator, which will automatically adjust valve position to compensate for either increase or decrease in duct pressure. Adjustable set points provided to set maximum and minimum cfm. Reverse acting control sequence must be used. Bleed rate 25 scrim. Integral flow ring taps and calibration chart shall be provided on unit.

N. Manufacturer: Trane VFWC, Titus, Price FDV, FDVLP, FDC, FDCLP, Carnes, Enviro-Tec, Nailor 35P (parallel boxes), 35SST (Series), Krueger, Anemostat or equal.

2.24 DUCT SILENCERS

A. Sound traps shall be IAC Acoustics, Vibro-Acoustics, Aerosonics, United McGill, Pottorff, Ruskin, Nailor or equal. Sound traps shall be sized for a maximum air pressure drop and maximum air velocity as noted on schedule.

B. Materials

1. Outer casings of rectangular silencers shall be made of 22-gauge type #G-90 lock-former-quality galvanized steel.
2. Interior partitions for rectangular silencers shall be not less than 26-gauge type #G-90 galvanized lock-former-quality perforated steel.
3. Filler material shall be as indicated on the Schedules and as appropriate for the application:
   a. Standard fill: Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof.
   b. Encapsulated fill for hospital or clean room applications: Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof. Filler material shall be totally encapsulated and sealed with polymeric film of an appropriate thickness. The encapsulated fill material shall be separated from the interior perforated baffles by means of a noncombustible, erosion resistant, factory-installed, acoustic stand-off. It shall not be acceptable to omit the acoustic stand-off and try to compensate for its absence by means of corrugated baffles.
   c. Packless sound traps: No sound absorptive material of any kind is to be used in the silencers. The silencers shall attenuate air/gas transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.
   d. “Green” fill alternate: Acoustic fill material shall be 100% environmentally friendly, and constructed of recycled natural fibers. Each fiber shall be treated with an EPA registered fungal inhibitor in order to prevent mold, mildew, fungi, and pest protection. The fill material must not contain any harmful chemicals, irritants, and/or volatile organic compounds (VOCs) in order to prevent off-gassing.
4. Combustion ratings for the silencer acoustic fill shall be not greater than the following when tested to ASTM E 84, NFPA Standard 255, or UL No. 723:
   a. Flame Spread Classification: 25
   b. Smoke Development Rating: 50

C. Construction
1. Units shall be constructed in accordance with the ASHRAE Guide recommendations for high pressure duct work. Seams shall be lock formed and mastic filled. Rectangular casing seams shall be in the corners of the silencer shell to provide maximum unit strength and rigidity. Interior partitions shall be fabricated from single-piece, margin-perforated sheets and shall have die-formed entrance and exit shapes so as to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator. Blunt noses or squared off partitions will not be accepted.
2. Attachment of the interior partitions to the casing shall be by means of an interlocking track assembly. Tracks shall be solid galvanized steel and shall be welded to the outer casing. Attachment of the interior partitions to the tracks shall be such that a minimum of 4 thicknesses of metal exist at this location. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the silencer for consistent aerodynamic and acoustic performance. Interior partitions shall be additionally secured to the outer casing with welded nose clips at both ends of the sound attenuator.
3. Sound attenuating units shall not fail structurally when subjected to a differential air pressure of 8-inches water gauge from inside to outside the casing. Airtight construction shall be provided by use of a duct sealing compound on the jobsite material and labor furnished by the contractor.

D. Acoustic Performance
   1. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with ASTM Specification E477-99. The test facility shall be NVLAP accredited for the ASTM E477-99 test standard. Data from a non-accredited laboratory will not be acceptable. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves, and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels both for FORWARD FLOW (air and noise in same direction) and REVERSE FLOW (air and noise in opposite directions) with airflow of at least 2000 fpm entering face velocity. Data for rectangular and tubular type silencers shall be presented for tests conducted using silencers no smaller than the following cross-sections:
      a. Rectangular, inch: 24x24, 24x30, or 24x36, and
      b. Tubular, inch: 12, 24, 36, and 48

E. Aerodynamic Performance
   1. Static pressure loss of silencers shall not exceed those listed in the silencer schedule as the airflow indicates. Airflow measurements shall be made in accordance with ASTM specification E477-99 and applicable portions of ASME, AMCA, and ADC airflow test codes. Tests shall be reported on the identical units for which acoustic data is presented.

2.25 CONSTANT AIRFLOW REGULATORS

A. Constant Airflow Regulators are modulating orifices that automatically regulate supply, return or exhaust airflows in duct systems to constant levels. The passive control element responds to duct pressure and requires no electric or pneumatic sensors or controls. The device shall compensate for changes in duct pressure caused by thermal stack effect, building pressure, dust-clogged filters, etc. The device shall solely operate on duct pressure and require no external power supply.

B. Constant Airflow Regulators shall be capable of maintaining constant airflow within +/- 10% of scheduled flow rates (15% for units 50 CFM or less), within the operating range of 0.2 to 0.8 in. wg (50 to 200 Pa) differential pressure, or 0.6 to 2.4 in. wg on high-pressure models, or 0.1 to 0.42 in. wg on low-pressure models. Each regulator shall be pre-set and factory calibrated, requiring no field adjustment to the airflows as indicated on the schedule, and shall be rated for use in air temperatures ranging from -25° to 140°F (-32° to 60°C.)

C. The active control element is an aerofoil. The aero-wing damper lifts in response to increasing static pressure. This operation regulates the free-area opening through the control, resulting in maintenance of velocity and specific airflow set points.

D. Regulators shall be provided as an assembly consisting of a steel or UL ABS plastic body housed within a round sleeve for mounting in round duct. Each round sleeve must be fitted with a lip gasket to ensure perimeter air tightness with the interior surface of the duct. All regulators must be classified per UL 2043 and carry the UL mark indicating compliance. All Constant Airflow Regulators will require no maintenance and must be warranted for a period of no less than five years. Constant Airflow Regulators shall be installed in tight ducting systems in accordance with all applicable codes and manufacturer’s instructions

E. American Aldes Ventilation #Series CAR-II or equal.

2.26 AIR BLENDERS

A. Prove air blenders of size as shown on Drawings, constructed of heavy gauge aluminum, all welded. Units shall be factory constructed and tested, and installed in accordance with manufacturer's recommendations. RM Products Co, Blender Products. or equal.

2.27 UNDERGROUND DUCTWORK

A. General
1. Complete duct system (including: plenums, round duct, run-outs, diffuser boots, etc.) must be from one manufacturer and be of the same material, construction and connection method throughout. Field fabricated duct components are NOT acceptable.
2. All duct and fittings shall be constructed per SMACNA's Duct Construction Standards (+10 wg).
3. Provide elbows, duct, diffusers, plenum, clamp & gasket, boots, saddle registers, caulk, water gauge test and adapters as required by drawings for underground installation.

B. System
1. Ductwork shall be HDPE, closed cell plastic material that is recyclable, does not emit volatile organic compounds, and conforms to ASTM-D2412. Ductwork shall be resistant to mildew, mold (UL 181B), and radon gas (BSS 7239-88). Ductwork shall not rust or crack under external stress or strain. Ductwork shall have R-10 thermal insulation value without the use of external insulation.
2. All joints shall be gasketed and sealed. Clamps and gaskets shall be used on ductwork without flanges. Clamps shall be polyethylene with 410 stainless steel plates and stainless steel screws. Gaskets shall comprise of 1/4" thick butyl rubber sealant tape with silver polyester facing that is water and UV resistant and shall not stain. Gaskets shall comply with ASTM-E84 for flame and smoke spread.
3. Flanged joints and duct branches shall use a co-polymer adhesive caulking sealant that is water and UV resistant. Flanges shall be connected with stainless steel bolts.
4. Assembled ductwork shall be able to maintain +/- 10" static pressure with no leakage.
5. Assembled ductwork shall be approved for installations 48" below flood plain elevation without water intrusion.
6. Duct system installed by manufacture trained installer will be an air and water tight system.
7. Fiberglass style ductwork or PVC coated galvanized steel ductwork shall NOT be acceptable.
8. Duct system shall carry a 10-year warranty.

C. Manufactures: Blue Duct by AQC Industries or equal.

PART 3 - EXECUTION

3.1 DUCTWORK GENERAL REQUIREMENTS

A. Fabricate ducts with galvanized sheet steel, except as otherwise indicated and as follows:
1. All duct system appurtenances are to be the same material as ductwork including volume dampers and access panels.
2. Humidifier ductwork: Ductwork for humidifiers shall be constructed of 20-gauge stainless steel ductwork with longitudinal seam at top of horizontal runs and all joints sealed watertight. Duct length shall be as required by humidifier manufacturer, or as shown on drawings whichever is greater, to allow for full absorption of water vapor. This portion of duct shall include an integral drain pan and drain line connection.
3. Shower Rooms: Exhaust ductwork serving shower rooms or other wet areas shall be constructed of stainless steel or aluminum. Where shower room exhaust ducts connect to a general exhaust riser, the non-ferrous ductwork with sealed joints need only extend to point of connection to the general exhaust riser.
4. Environmental exhaust ductwork serving domestic clothes dryers shall be constructed of metal and shall have smooth interior surface. Provide backdraft damper at discharge to atmosphere.
5. Underground Ducts:
   a. Install per manufacturer's instructions.
   b. Install ductwork when outdoor temperatures are no lower than 20°F and do not exceed 95°F.

c. Slope ducts at 1/8 inch per foot (minimum) to allow for drainage to an accessible low point for maintenance.
d. All underground ductwork shall be pressure and leak tested prior to backfilling and prior to installation of concrete. Leak test report shall be submitted to Owner's Representative for review and approval.
e. Provide pea gravel or sand back fill all around ductwork.

6. Non-toxic and non-hazardous wet vapor exhaust, such as dishwasher, sterilizers, cart washers, and shower exhaust systems:
   a. Material: Type 304 or 316L stainless steel, minimum 24-gauge spiral or sheet metal ductwork with G90 zinc coating. Type 304 or 316L stainless steel fittings.
   b. Joints: welded, or swaged lap-joint with silicon caulk and stainless steel sheet metal screws.
   c. All accessories shall be stainless steel including dampers, damper hardware and turning vanes.
7. Hazardous/corrosive chemical exhaust, Radio-Isotope hood, and Bio-safety cabinet exhaust:
   a. Material: Type 316L stainless steel, minimum 18-gauge fully welded ductwork and fittings. Approved G90 galvanized steel may be used where required by local authority.
   b. Joints: TIG welded. Weld may be either butt-weld or swaged joint with lap weld with lap running in direction of airflow. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork not required.
   c. All accessories shall be 316 stainless steel including dampers, air valves, damper hardware, etc.
   d. Pressure testing: Refer to pressure classification and testing procedure table this specification section.
8. Chemical fume hood exhaust:
   a. Material: Type 316L stainless steel, minimum 18-gauge ductwork and fittings.
   b. Joints: TIG welded. Weld may be either butt-weld or swaged joint with lap weld with lap running in direction of airflow. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork not required.
   c. Flanges: Manufactured 309 stainless steel clamp and frame.
   d. All accessories shall be 316 stainless steel including dampers, air valves, damper hardware, etc.
   e. Pressure testing: Refer to pressure classification and testing procedure table this specification section.
9. Perchloric Acid Fume Hood Exhaust:
   a. Material: Type 316L stainless steel, minimum 10-gauge fully welded ductwork and fittings.
   b. Joints: TIG butt welded. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork required to achieve a smooth and slag free interior joint bead
   c. All accessories shall be 316 stainless steel.
   d. Pressure testing: refer to pressure classification and testing procedure table this specification section.
10. Magnetically or Electrically sensitive rooms, including MRI rooms:
    a. All ductwork, fittings, grilles/diffuser, screws, etc, shall be constructed of aluminum in and around magnetically/electrically sensitive rooms. Refer to all construction documents for location of these critical rooms.

3.2 DUCTWORK CONSTRUCTION AND SEALING CRITERIA

A. Leakage classification of ductwork shall conform to the minimum requirements of Table 3.1 and Table 3.2 based on procedures of "SMACNA HVAC Duct Construction Standards-Metal and Flexible" and "SMACNA HVAC Air Duct Leakage Test Manual" as follows:

TABLE 3.1
DUCT LEAKAGE CLASSIFICATION

DUCT WORKING PRESSURE CLASS	AIR PRESSURE LESS THAN +/-0.5"WC	AIR PRESSURE +/-0.5" TO +/-2.99"	AIR PRESSURE +/-3" TO +/-10" WC
SMACNA Seal Class	C	B	A
Sealing Applicable	Transverse joints	Transverse joints and longitudinal seams	Transverse joints longitudinal seams and all duct wall penetrations
LEAKAGE CLASS			
Rectangular sheet metal SMACNA Leakage Class	6	6	4
Round sheet metal SMACNA Leakage Class	6	4	2
Note: Duct sealant ranges and classification are generally more restrictive than SMACNA.			

B. Ductwork shall be constructed to SMACNA pressure class based on 150% of the maximum working pressure at connection to air handling unit, or better as specified herein. Unless called out otherwise on drawings the pressure classification of ductwork shall be as follows:

TABLE 3.2
DUCT CONSTRUCTION CLASSIFICATION

DUCT SYSTEM	LOCATION	WORKING PRESSURE (ESP FROM SCHEDULE)	BUILD TO SMACNA PRESSURE CLASS	BUILD TO SMACNA SEAL CLASS
Outdoor air intake	From outdoor air intake to AHU	-1" wc	-2" wc	B
Low pressure supply air	Downstream of air terminal units to grilles, registers or diffusers.	+0.5"	+1" wc	B
Low pressure supply air	From AHU to grilles, registers or diffusers.	+0.5 wc	+1" wc	B
Low pressure return air	From return grilles to AHU	-0.5" wc	-1" wc	B
Transfer air	From grille to grille, or acoustic boots or "z" bends	-/+0.25" wc	-/+0.5" wc	C
Med pressure supply air	From AHU to air terminal units	+6" wc	+10" wc	A
Med pressure supply air	From AHU to air terminal units	+4" wc	+6" wc	A
Med pressure supply air	From AHU to air terminal units	+2" wc	+3" wc	A
Med pressure return air	From air terminal units to AHU	-3" wc	-4" wc	A
Med pressure return air	From air terminal units to AHU	-2" wc	-3" wc	B
Med pressure return air	From air terminal units to AHU	-1" wc	-2" wc	B

TABLE 3.2
DUCT CONSTRUCTION CLASSIFICATION

DUCT SYSTEM	LOCATION	WORKING PRESSURE (ESP FROM SCHEDULE)	BUILD TO SMACNA PRESSURE CLASS	BUILD TO SMACNA SEAL CLASS
Relief air	From AHU to discharge at outdoors	+1" wc	+2" wc	B
General exhaust	From grille to exhaust fan	-1" wc	-2" wc	B
General exhaust	From exhaust fan to discharge at outdoors	+1" wc	+2" wc	B
Toilet/shower room exhaust	From grille to exhaust fan	-1" wc	-2" wc	B
Toilet/shower room exhaust	From exhaust fan to discharge at outdoors	+1" wc	+2" wc	B
Type II Kitchen Hood vapor/ low temp, and dishwasher exhaust	From Hood or equipment to exhaust fan	-2" wc	-3" wc	A, or welded. Refer to specification
Type I Kitchen Hood medium/high heat, grease exhaust	From Hood to exhaust fan	-3" wc	-4" wc	A, or welded. Refer to specification
General Lab exhaust	Branches from grilles to air valve and mains to exhaust fan	-2" wc	-3" wc	A, or welded. Refer to specification
General Lab exhaust	From exhaust fan to discharge at outdoors	+1" wc	+2" wc	A, or welded. Refer to specification
Chemical fume hood and biosafety cabinet exhaust	From Hood to exhaust fan	-2" wc	-3" wc	A, or welded. Refer to specification
Chemical fume hood and biosafety cabinet exhaust	From exhaust fan to discharge at outdoors	+2" wc	+3" wc	A, or welded. Refer to specification
Boiler direct connection air intake	From outdoor air to boiler connection	-0.5" wc	-1" wc	B, or per boiler mfg. installation recommendations.
Gravity type boiler vent	From boiler connection to outdoor discharge	+0.5" wc	+1"	Seal per boiler vent mfg. installation recommendations
Pressure type boiler vent	From boiler connection to outdoor discharge	N/A	N/A	Seal per boiler vent mfg. installation recommendations
Dust collection exhaust	From floor machine tool to dust collector	-4" wc	-6 " wc	A, or welded. Refer to specification

3.3 DUCTWORK SPECIALTIES INSTALLATION

A. Ductwork is generally diagrammatically indicated and shall be generally installed as indicated. Do not scale Drawings for exact location of ducts. Install ducts to best suit field conditions and cooperate with other trades. Do not penetrate Structural members without consent of Architect or Structural Engineer. Check with Structural drawings prior to locating any penetrations. Duct sizes are indicated as net inside dimensions on the Drawings. The indicated dimensions shall be altered at the job site for the purpose of avoiding interferences and clearance difficulties to other dimensions producing the same air handling characteristics, provided such altered dimensions are approved by the Architect. Ducts shall be constructed in accordance with the latest edition of codes and standards identified in Part 1 and as shown on the Drawings.

1. Grilles, Registers and Diffusers: Install flush, squared, tightly sealed, and entirely covering sheet metal ductwork and gaskets. Thread sheet metal mounting screws tightly into sheet metal. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper only where individual duct mounted balancing dampers are specifically noted as not provided. Duct connections shall fit securely to necks or collars behind face area. Provide all necessary transition pieces and duct collars to make connections from ductwork to neck sizes. Where ducts connect directly to necks or collars provide a minimum straight duct section of two times the duct diameter to the last elbow. Where minimum straight duct sections are not physically possible provide sheet metal plenum sized for approximately 500 fpm air velocity with duct tapped directly to side of plenum. Where building walls, floors and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted and sealed to building structure.
2. Install turning vanes in all mitered elbows in all ducts, so that tips are parallel with the sides of the ducts. Tips of acoustical turning vanes on outside radius shall be flush with acoustical lining.
3. Provide flexible connections to completely isolate fans from direct contact with all sheet metal work.
4. Provide access doors, as required, for access to valves, controllers, dampers and humidifier dispersion tubes. Access doors required in Product Conveying Vapor/Moisture Ductwork (see applicable paragraph above) shall not be installed in the bottom of the duct or in a manner to allow leaks.
5. Volume Dampers: Provide manual volume dampers in all supply, return and exhaust branch and run-out ductwork to grilles, diffusers, registers, and other inlet and outlet openings to facilitate balancing of air distribution systems. These are to be provided as part of contract whether shown on plans or not. Where ceilings are not accessible, provide access door or remote damper regulator. Volume dampers must be installed immediately downstream of each duct takeoff.
6. Multi-Blade Control Dampers: Provide control dampers as shown on drawings. Coordinate with BAS system provider for control actuators.
7. Splitters and splitter dampers shall not be installed in medium or low pressure supply ductwork to VAV systems.
8. Clean and pretreat surfaces before application of sealant. Conform to the manufacturer's cleaning procedures. Install sealants in conformance with manufacturer's instructions.
9. Except where noted, vertical ducts or horizontal ductwork penetrating fire rated ceilings, roofs, walls and floors shall be fire separated with UL listed and labeled fire dampers installed per UL tested assembly including sleeves and retaining angles. Provide additional fire dampers indicated on the Drawings and as otherwise required by the IBC and building inspector. Provide approved firestopping between damper frames and firewalls. Install fire dampers in accordance with NFPA Standards, requirements of the State Fire Marshal, and applicable codes. Ensure that fire dampers are installed in the open position.
10. For penetration of fire rated partitions which meet the IBC Chapter Seven requirements of non-Group H occupancy penetration of tenant separation and corridor walls in buildings with

fire sprinklers provide metal sleeves as follows: A minimum 12 inch-long (0.30 m) by 0.060-inch-thick (1.52 mm) steel sleeve shall be centered in each duct opening. The sleeve shall be secured to both sides of the wall and all four sides of the sleeve with minimum 1-1/2" by 1-1/2" by 0.060-inch steel retaining angles. The retaining angles shall be secured to the sleeve and the wall with No. 10 screws. The annular space between the steel sleeve and wall opening shall be filled with rock wool batting on all sides.

B. Hangers and Supports: Securely fasten all ductwork to the building construction by means of hangers, supports, guides, anchors, and sway braces to maintain duct alignment, to prevent sagging, and to prevent noise and excessive strain on ductwork due to movement under operating conditions.
   1. Maximum spacing between hangers shall not exceed ten (10) feet for rectangular sheet metal ductwork and twelve (12) feet for spiral round sheet metal ductwork. Provide hanger at each change in direction and at each branch takeoff. Refer to "SMACNA HVAC Duct Construction Standards Metal and Flexible" for additional requirements.
   2. Provide duct supports within two (2) feet of each: duct elbow; connection to flexible ductwork; connection to terminal units; connection to fan coil units; connection to exhaust fans, connection to air handling units, and fire and/or smoke dampers.
   3. Adequately mount and anchor all material and equipment as required. Include lateral bracing as required to prevent horizontal, seismic movement. Refer to IBC and Architectural and Structural Drawings for seismic requirements.
   4. Do not support ductwork from other ducts, pipes, fans or any other pieces of equipment.
   5. Powder driver fasteners shall not be used to support rectangular ducts larger than 40" maximum dimension. Powder driven fasteners shall not be allowed in existing facilities.
   6. Support round duct, larger than 36", shall have two hangers at each support point.
   7. Hangers and supports shall conform to SMACNA section "Hangers and Supports". Nail inserts, hangers and supports to formwork before slabs are poured. Cut off or remove nails, strap-ends and other projections, flush with concrete after forms are removed.
   8. Support vertical ducts, passing through floors with two continuous angles screwed to the duct and bearing to the floor and conforming to SMACNA section "Riser Support-From Floor". Blocking or shimming ducts will not be permitted.

C. Other:
   1. Fans: Align fans, motors, and drives. Install fans to render bearings accessible for lubrication without dismantling fans or ducts. Provide extended bearing oilers as required. Mount all fans on vibration isolators as specified.
   2. Insulation: Properly and neatly apply insulation on all material and equipment and apparatus, as specified, including all fittings. Apply insulation over clean, dry surfaces, with adjoining sections firmly butted together and canvas smoothly pasted over. When vapor barriers are specified, install continuous overall external surfaces of the entire system.
   3. Duct Sizing: Where duct sizes are not specifically shown on the plans or must be modified due to physical limitations, supply ducts may be sized at a maximum velocity of 1,500 fpm or 0.08" sp friction per 100 feet, whichever provides the larger duct, and return/exhaust/intake ducts may be sized at a maximum velocity of 1,000 fpm or 0.06" sp friction per 100 feet, whichever provides the larger duct. Refer to Basis of Design for further duct sizing criteria.
   4. Humidifiers: Humidifier installation shall be approved by manufacturer and coordinated with all other systems. Condensate piping shall include p-traps as recommended by the humidifier manufacturer. Insulate exposed piping as required by the code
   5. Exterior Ductwork: Ductwork located and installed outside the building envelope, on roof, grade or other location exposed to weather, shall be constructed and sealed airtight and watertight. The top of exterior ducts shall be crossbroken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.
   6. Double Wall Ductwork: Insulated ductwork located and installed outside the building envelope may be constructed of two layers of galvanized sheetmetal encapsulating the insulation layer.

The inner duct shall be constructed as the main carrier duct with gauge and fabrication as required per the SMACNA Duct Construction Standards and minimum 24-guage. The insulation layer shall be provided as required by the local energy code or Section 230713 Duct Insulation, whichever is greater. The outer sheetmetal layer shall be a non-pressurized layer, minimum 24-gauge, to encapsulate the insulation layer to prevent weather degradation and optimize the insulation effectiveness for the life of the building. The top layer shall be crossbroken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.

7. Access Floor Diffusers: The mounting ring for floor mounted diffusers are to be affixed to the floor tiles using a clamp insert or other method approved for use with the floor diffuser.

3.4 FLEXIBLE DUCTWORK INSTALLATION

A. Flexible insulated round ductwork connectors may be utilized where shown on the Drawings and for transitions between air handling equipment and rigid ductwork. A five (5) foot (maximum) length of flexible air duct shall be allowed to be used as an elbow at a terminal devices or air outlet/inlet, unless shown otherwise on the Drawings. No intermediate joints are allowed. Seal each end using two wraps of tape listed in accordance with UL 181B and marked 181B-FX, followed by a mechanical stainless steel screw operated drawband. Plastic drawbands are not allowed. Support duct to maintain smooth shape without sagging. All connections shall utilize welded conical tees, aluminum conical fitting, Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted. Damper regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

B. Flexible duct runouts to diffusers and grilles is limited to the following sizes:
   1. 6” diameter: Up to 100 cfm
   2. 8” diameter: Up to 200 cfm.
   3. 10” diameter: Up to 360 cfm.
   4. 12” diameter: Up to 600 cfm.
   5. 14” diameter: Up to 900 cfm.

3.5 EXPANSION JOINTS

A. At a non-rated penetration through an expansion joint:
   1. Provide insulated flexible ductwork through expansion joint. Flexible connector shall be no longer than five feet between segments of rigidly attached ductwork.

B. At a fire/smoke rated penetration through an expansion joint:
   1. Provide required fire/smoke damper with sleeve through rated assembly as required by Building Code and manufacturer’s instructions. Provide breakaway duct connections as required by manufacturer’s listing. Ductwork bracing on either side of wall must not be rigid within ten feet of wall to allow for building movement. Seismic restraints must not be closer than ten feet of expansion joints on either side of wall. During a building movement event the ductwork will need to be reattached to fire/smoke damper.

3.6 COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Grease exhaust ducts for Type I hoods shall be constructed of 16-gauge steel or 0.044" stainless steel with liquid tight welded or brazed joints in accordance with the mechanical code, and/or manufactured grease duct assemblies may be utilized. Do not use turning vanes or dampers. Grease exhaust ducts located outside the building envelope may utilize mechanical fittings. Coordinate with architectural design for shaft enclosures.

B. As an alternate method to enclosing the duct in a rated shaft enclosure - furnish and install on the exhaust duct, a 2-hour fire rated board or blanket wrap. See Section 230713 HVAC Insulation for specification. Coordinate with local AHJ and Fire Marshal requirements.

C. As an alternate method to enclosing the duct in a rated shaft enclosure - furnish and install fire resistive coated ductwork. Refer to Section 233633 Fire Resistive Ductwork and Accessories. Coordinate with local AHJ and Fire Marshal requirements.

D. As an alternate method to enclosing the duct in a rated shaft enclosure. Furnish manufactured double wall, factory built grease duct assembly for use with Type I kitchen hoods, which conforms to the requirements of NFPA-96. Products shall be ETL listed to UL-1978 and UL-2221 for venting air and grease vapors from commercial cooking operation. Double wall grease ducts shall be listed for a continuous internal temperature of 500°F and intermittent temperatures of 2000°F. The duct sections shall be constructed of an inner duct wall and an outer wall with insulation in between. The inner duct wall shall be constructed of .036-inch-thick (minimum), 430 type stainless steel and be available in diameters 8" through 24". The outer wall shall be constructed of stainless steel at a minimum of 0.024-inch thickness (minimum). The duct shall include layers of insulation between the inner and outer wall. Grease duct joints shall be held together by means of formed clamps and sealed with fire caulking. Ductwork Manufacturer: Captive Aire #DW Series or equal. Fire Caulking Manufacturer: 3M Fire Barrier 2000+ or equal.

E. Install commercial kitchen hood exhaust ducts without dips or traps and slope a minimum of 2 percent to drain grease back to the hood. Increase slope as required by local code.

F. Provide bolted access doors at each elbow and at the base of each riser sized to allow proper cleaning. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet (3.7 m) in horizontal ducts, and at every floor for vertical ducts, and where indicated on Drawings.

G. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and AHJ.

H. Provide reinforcement spacing for grease exhaust ducts at no greater than 48”(1.2 m) spacing, or less, as required to prevent duct flexure and as required by code and SMACNA.

3.7 DUCT SILENCER REQUIREMENTS

A. Install the duct silencer per manufacturer's basic installation instruction.

B. Do not locate duct silencers within one duct diameter from fan discharge/intake openings, elbows, or takeoffs.

C. Where multiple duct silencer units are grouped together in parallel within the duct system they shall be sealed airtight at all joints.

3.8 FABRIC AIR DISPERSION SYSTEM

A. Clean each air handling unit and rigid ductwork prior to installing the fabric air dispersion duct system.

B. Temporary Closure: At ends of ducts which are not connected to equipment of distribution devices at time of ductwork installation, cover with fire retardant film or other covering which will keep the ductwork system clean until installation is completed.

C. If fabric air dispersion system becomes soiled during installation, these sections should be removed and cleaned following the manufacturer’s standard terms of laundry.

3.9 STAINLESS STEEL DUCTWORK

A. For installations serving moisture, vapor, or fume exhaust.
   1. For connections to hoods or equipment provide minimum 12” length flanged and bolted stainless steel spool piece connection.
   2. All fittings shall be long radius. Round elbows shall be minimum 5-gore.
   3. Slope horizontal ductwork back toward source connected equipment minimum 1% slope so that moisture and liquids may drain back toward equipment.
   4. Low point “traps” in the ductwork shall be fitted with a low point drain valve, 1/2” welded connection, stainless steel piping and valve.
   5. All welding to be completed by certified welders experienced in 316 stainless steel.

3.10 DUCTWORK SEALANT METHODS

A. General
   1. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
   2. All installation shall be in accordance with manufacturer’s published recommendations.
   3. Cleanliness:
      a. Before installing sealant, Surface must be dry and be free of dirt, oil, grease, and loose or foreign matter that could impair adhesion wipe ductwork to a visibly clean condition.
      b. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.
      c. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
      d. Follow the Advanced Level requirements as found in the SMACNA Duct Cleanliness for New Construction Guidelines.

B. Installation of Mastic/Sealant Duct System
   1. One Part Sealant System:
      a. Apply one-part sealant system at a 20 to 30 wet mil thickness with a brush, putty knife; caulk gun or spray to duct joints, fasteners and seams. Tool, if necessary, caulk bead with putty knife or brush. Let dry per manufacturer data sheet of a minimum of 48 hours.
   2. Or, One Part Spray Applied Sealant System:
      a. Use a manufacturer approved airless sprayer capable of application pressure up 2,000 psi spraying through a minimum 0.111 tip. Apply in a smooth application perpendicular to the substrate at a rate of 20 to 30 wet mils to joints, seams and duct wall penetrations per manufacturer’s technical data sheet. Let dry per manufacturer data sheet of a minimum of 48 hours.

C. Installation of Mastic/Sealant Duct System with 10-Year Warranty
   1. Installation of Rolled Sealant Tape over Mastic/Sealant:
      a. Cut desired length for each side of the ductwork; peel off release liner and center over joint, seam or penetration. The rolled sealant should completely cover the sealant. Use hand pressure to place the rolled sealant followed by a squeegee application. Lap tape end 2 inches (50 mm minimum). Squeegee rolled sealant to insure bond and complete adhesion to the duct. Instant adhesion requires precise positioning. Not re-positional. Four-Bolt flange requires applying corner pieces prior to applying the edge strips.

D. Field Quality Control
   1. Allow duct sealant system to cure minimum 48 hours before pressure testing for the fluid applied Sealants. Rolled sealants can be tested immediately with duct leakage tester.
   2. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

3. Notify Owner's Representative a minimum of seven (7) calendar days in advance of leakage testing.
4. Leaks identified during ductwork air leakage testing shall be repaired by:
   a. Complete removal of the sealing materials.
   b. Thorough cleaning of the joint surfaces.
   c. Installation of multiple layers of sealing materials.
5. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

3.11 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.12 DUCT SEALING ALTERNATIVE

A. Occasionally a ducted system will experience leaks after the ductwork has been installed and sealed per one of the SMACNA duct sealant classifications. These leaks may not be identifiable until after ductwork has been installed and system air balancing and leakage testing has been engaged. At the contractor's option an alternative solution to sealing such leaks may include the use of a water based sealing agent that is introduced to the interior of the duct system.
   1. Manufacturer: Aeroseal LLC or approved equal. Application must be performed by manufacturer approved provider.
   2. Sealant must be UL 723 approved for smoke and flame spread.
   3. Sealant must be UP 181 approved for humidity, mold growth, temperature, erosion and puncture resistance.

B. Duct Sealing Procedure:
   1. Preparation:
      a. Inspect the entire duct shaft and horizontal plenums for major leakage sites (larger than 1/2" across).
      b. Mechanically clean duct shaft per NADCA (National Air Duct Cleaners Associations) standards if more than 1/8" of surface contaminants are visible on duct surfaces.
      c. Repair all major leakage sites using mastic and fiberglass mesh tape per SMACNA standards.
      d. Temporarily remove or protect all building controls and smoke detectors from aerosol particles as recommended by the Manufacturer.
      e. Temporarily disable fire alarms and notify appropriate authorities.
      f. Temporarily isolate air-moving equipment and block off air inlets and air outlets as recommended by the manufacturer.
      g. Protect occupied spaces from aerosol particles as recommended by the Manufacturer.
      h. Protect air-moving equipment, air inlets and outlets and other devices and appurtenances as recommended by the manufacturers.
   2. Duct Sealing:
      a. Seal existing ductwork from the inside using automated aerosolized sealant injection as recommended by manufacturer or by manually caulking internally with sealant.

b. Sealant must cure within 2 hours with no odor or VOC off-gasing thereafter.
c. Sealant shall remain elastic (not harden rigidly) after curing.
d. Sealant shall be deposited substantially at areas of leakage only, and shall not coat interior duct walls, duct lining material, dampers, or turning vanes.
e. Seal all test holes using patching plates sealed with mastic.
f. Repair or replace insulation to match existing.
g. Seal all injection openings with duct access doors or replace ductwork to match existing.

3. Duct Reassembly and Cleanup:
   a. Reinstall building controls and smoke detectors.
   b. Enable fire alarms and notify appropriate authorities.
   c. Remove blocking, reinstall grills and registers, and enable air handling fans.
   d. Cleanup sealant residue that may have adhered to surfaces in occupied areas as recommended by the Manufacturer.
   e. All work shall be done in a substantial and workmanlike manner by factory-trained technicians.
4. Testing:
   a. Provide pre-sealing and post-sealing leakage profile reports indicating percentage reduction of duct leakage for both supply and return ductwork.
   b. Retest ductwork and document compliance with air leakage requirements as identified in section 230593 Testing, Adjusting and Balancing.
5. Warranty:
   a. The Contractor shall warrant that the aerosol sealant application will be free from defects for a period of 3 years from date of the sealing application. If defects should occur during this period, the Contractor shall repair or replace the defective duct seals, including the direct labor costs for performing the repair or replacement, at no additional cost to the Owner.

3.13 FIBERGLASS DUCTWORK INSTALLATION

A. Fiberglass ductboard may be utilized as an option to sheet metal ductwork in the following applications and where indicated on the drawings:
   1. Return air transfer ducts between two adjacent rooms with maximum design static pressure in the following range: -0.5" w.g. to +0.5" w.g.

3.14 FIRE AND COMBINATION FIRE/SMOKE DAMPER INSTALLATION

A. Install per manufacturer’s and UL installation requirements.

B. For buildings with no fire alarm system all fire/smoke dampers shall be interconnected with the HVAC unit’s controls and duct smoke detectors. The detection of smoke at any fire/smoke damper shall stop for HVAC unit fans and close all fire/smoke dampers. A single test/reset station shall be capable or resetting all devices back to normal operation.

3.15 CONTROL DAMPER INSTALLATION

A. Note that installation of control dampers is a part of the mechanical contractor’s work regardless of whether they are specified in this section or as part of products to be selected by the Control Contractor.

B. When electric actuators are provided, dampers shall be installed to allow direct over the shaft mounting of actuators. No connecting rods and stand off brackets shall be necessary.

C. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking (parallellogramming), bowing, or other installation error.

D. Blades shall close completely. Leakage shall not exceed manufacturer's specifications at rated static.

E. Structural support shall be provided as necessary for all multi-section dampers.

F. Where blankoffs or structural supports obstruct duct or air passages, the decrease in free area shall not exceed 15% of the damper face area unless otherwise specified here or on plans.

G. No individual damper section may exceed 20 sq. ft.

H. Dampers shall be parallel blades style for outside air economizer to facilitate improved mixing of outside air and return air. Airflows shall be directed towards each other.

I. Where ducts penetrate an exterior surface install a Class I motorized damper at each outdoor air supply opening, exhaust opening, relief outlet, shaft vent and stairway vent, as required to comply with minimum requirements of the local Energy Code.
   1. Dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the system served requires outdoor air or exhaust air or operates continuously or the dampers are opened to provide intentional economizer cooling.
   2. Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

3.16 SEISMIC REQUIREMENTS

A. See Section 230549 for specific requirements.

B. All HVAC equipment and machinery shall be anchored to withstand forces generated by earthquake motions. As a minimum, equipment and equipment frames shall be designed to withstand a force of 100% of the weight of the equipment and frame acting at its center of gravity. Anchorage of the equipment and/or frame to the structure shall be for a force of four times gravity also acting at the center of gravity.

C. The seismic calculations shall be the responsibility of contractor.

D. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA-Seismic Restraint Manual: Guidelines for Mechanical Systems and ASCE/SEI 7.
   1. Space lateral supports a maximum of 40 feet (12 m) and longitudinal supports a maximum of 80 feet (24 m) on center.
   2. Brace each change of direction longer than 12 feet (3.7 m).

E. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

G. Install cable restraints on ducts that are suspended with vibration isolators.

H. Install seismic-restraint devices using methods approved by the AHJ.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

J. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the

Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.17 EQUIPMENT

A. Install equipment as shown on plans and in accordance with manufacturer's installation recommendations.

3.18 SUPPLY DIFFUSER AND REGISTER LOCATIONS

A. Coordinate location of supply outlets with ceiling mounted smoke detectors. Locate outlets or outlet distribution so as to prevent airflow from inhibiting the operation of smoke detectors. Locate ceiling outlets a minimum of 3'-0" from smoke detectors.

3.19 PAINTING

A. Where the interior surfaces of ductwork are visible through the blades of supply outlets, return inlets, and exhaust inlets - paint the interior visible surfaces with one coat of flat black paint.

B. Ductwork exposed on the roof or exterior to the building shall be painted. Coordinate with Division 9 for requirements.

3.20 FIELD QUALITY CONTROL

A. Do not insulate or conceal ductwork before inspection by Owner's Representative, Architect or Engineer. If ductwork is insulated and concealed prior this inspection the Contractor shall remove insulation and ceiling to permit inspection at no additional cost to the Owner. The Contractor shall replace the insulation and ceiling after final inspection at no additional cost to the Owner.

B. Ductwork Deflection Criteria:
   1. Maximum inward and/or outward deflection at sheet metal panels shall be 3/4" under maximum static pressure operating conditions. Additional intermediate stiffening angles shall be installed where deflections exceed 3/4".
   2. Maximum inward and/or outward deflection at sheet metal elbows and joints shall be 1/4" under maximum static pressure operating conditions. Additional stiffening angles shall be installed where deflections exceed 1/4".

C. Acceptance of duct systems shall be contingent upon conformance with the requirements specified in Section 230593 "Testing, Adjusting and Balancing".

3.21 DUCTWORK LEAKAGE TESTING

A. Refer to Section 230593 Testing, Adjusting and Balancing for air leakage testing requirements and procedures.

B. Ductwork leakage testing may be required to meet local mechanical code and/or energy code requirements as defined in SMACNA HVAC Air Duct Leakage Test Manual.

3.22 ADJUSTING AND CLEANING

A. Clean the inside of plenums, casings, enclosures, fans, and accessible ductwork before starting fans. Blowout coils and condensate piping with compressed air. Comb all coil fins that may be bent. Install a clean set of filters in each system prior to testing and balancing. Proceed with testing and balancing. All dampers shall be locked in place.

END OF SECTION 233113

SECTION 233415

UNIT VENTILATOR

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 1, and shall include, but not necessarily be limited to, the following:
   1. Unit ventilators

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230716: Equipment Insulation

D. Section 230900: Building Automation System (BAS) Controls

E. Section 233113: Air Distribution

F. Division 26: Electrical

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430, "Central-Station Air Handling Units."

C. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:
   1. Air Movement and Control Association (AMCA):
      a. 99 - Standards Handbook
      b. 210 - Laboratory Methods of Testing Fans for Rating [Unit shall bear AMCA Certified Rating Seal]
      c. 300 - Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal]
      d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
      e. 500 - Test Method for Louvers, Dampers, and Shutters
   2. American National Standards Institute (ANSI):
      a. 9 - Load Ratings and Fatigue Life for Ball Bearings
      b. 11 - Load Ratings and Fatigue Life for Roller Bearings
      c. 900 - Test Performance of Air Filter Units
   3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
      a. 350 - Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
      b. 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
      c. 430 - Central-Station Air-Handling Units
      d. 440 - Room Fan-Coil Air-Conditioners
   4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
      a. 15 - Safety Code for Mechanical Refrigeration

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems
7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, and finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of 1/4” per one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.5 ENVIRONMENTAL REQUIREMENTS

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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect equipment and products against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.7 SAFETY PROVISIONS

A. Provide all open drives and fan wheels subject to maintenance and potential entanglement with protective guards or screens meeting OSHA requirements.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 UNIT VENTILATORS

A. General:
1. Furnish and install in accordance with the manufacturer's instructions, unit ventilators of the type and size indicated in the plans. These unit ventilators shall be operated with automatic controls provided by the supplier as described in the appropriate section of this specification. All units are ARI certified and conform with the latest ANSI standards for safe and efficient performance.
2. Unit ventilators shall be 30" high and 15-1/4" deep. They shall be constructed of 16 gauge furniture quality steel, with exposed edges rounded. Precise panel fit-up is required.
3. Front panels shall be retained by a minimum of three Allen wrench operated camlocks. The camlock heads shall be surrounded by a plastic inset to prevent paint damage.
4. All steel unit ventilator surfaces shall be cleaned, phosphatized, polished, rinsed and dried before application of final finish coat. The final finish shall be applied by an electrocoat paint system. Paint film shall be at a dry film thickness of 7/10 mil with no visible run marks. Units shall be supplied in one of eight decorator colors as selected by the architect.
5. Unit ventilator discharge grilles shall be constructed of heavy steel bars welded in place as an integral part of the unit structure. Easily cleaned sight block-offs shall be installed below the grille in the end pockets.
6. Unit inlet grilles shall be easily removable for easy filter access by loosening two camlocks.
7. Unit ventilator end pockets shall be at least 13" wide and provided with removable outside ends to allow fullest access for easy field installation of valves and piping. The unit shall have large pipe access openings in the bottom of both end pockets and large knockouts for piping and electrical connection in the back of both ends. Pipe chase across the back of the unit for field installation of crossover piping or running of electrical wiring as required.
8. Leveling legs shall be provided at both ends of the unit to facilitate alignment and leveling.

B. Dampers:
1. Unit ventilators shall be equipped with dual blade type mixing dampers to ensure proper modulation and mixing of return and outdoor air. A continuous divider shall be placed between the damper blades to separate the fresh air and return air compartments and positively prevent blow-through.
2. Bypass dampers shall be aluminum and insulated for sound attenuation and to prevent formation of condensate. Dampers shall be tight sealing and designed to minimize heat pickup in bypass.

C. Ultra-Low Leak Dampers:
1. Ultra-low leak damper option on vertical units shall be provided by utilizing medium density closed cell EPDM material seals. The seal shall be fixed and not part of the damper assembly. The outside air damper blade shall close into the closed cell EPDM material, providing a positive pressure seal. Leakage shall be less than one percent against 0.5 inches external static pressure.

D. Fan Board Assembly:
1. The unit ventilator fan board assembly shall be a single, rigid assembly and include the fans, fan housings, bearings, fan shaft and motor. The fan motor shall be mounted on the fan board.
2. The wrap around portion of the fan housings shall be constructed of six pound density molded fiberglass, at least 3/4" thick, and vinyl coated on the exterior surface.

E. Motors:
1. Motors shall be single speed permanent split capacitor with thermal overload protection. A multiple tap auto transformer shall be wired to the motor to provide different rpm settings and to insure rated capacity with all coil combinations. Motor speed shall not be affected by

damper positions or filter loading. The motor shall be easily removable without removing the fan board.

F. Coils and Drain Pans:
1. All hydronic coils shall be plate fin type and manufactured by the unit ventilator manufacturer. Fins shall be heavy gauge aluminum and have crack free continuous fin collars. Tubes shall be 5/8" x .020" wall copper.
2. Units shall be designed so a different type coil can be easily exchanged in the same basic unit. Substitution of chilled water or direct expansion coils for a heating coil shall not require revision on the basic unit or addition of insulation.
3. Unit drain pan shall be deep formed galvanized steel, lined internally with closed cell inert plastic insulating material.

G. Electric Coil:
1. Units equipped for electric heat shall have a heating element consisting of special resistance elements inserted in an extended surface fin tube bundle for maximum element life and safety. The maximum operational fin surface temperature shall not exceed 300°F. Units equipped for electric heat shall include, as standard, a high temperature cutout with a continuous sensing element. This device shall interrupt electrical power whenever excessive temperatures are sensed anywhere along the leaving side of the coil. A contactor shall also be included as standard to ensure positive disconnect of electric power whenever fan motor power is interrupted. All electric units shall have a power wiring console in the right end pocket to facilitate field wiring of the unit.

H. Filters:
1. Each unit shall be equipped with a single 1" thick (throwaway) (permanent) or (replaceable media) filter accessible without removal of the unit front panel.

I. Sound:
1. Sound data for the unit shall be based on tests in a sound laboratory reverberant room strictly conforming to ANSI S1.32-82. The test procedures for determining the unit sound level shall be in accordance with ARI Standard 350-86. Sound data must be accurate to with +3 db in the first and second octave bands and +2 db in the third through eighth octave bands.
2. Where the manufacturer's sound data is not published, the company must certify that sound data conforms with the above requirements. If the manufacturer cannot provide acoustical data in accordance with the requirements given above, the contractor must submit certified data that the specified units have been tested in an independent acoustics laboratory, capable of testing equipment at specified operating conditions, to determine sound power level by octave band.
3. Where units do not meet the specified maximum sound power level given, they must operate at reduced rpm so as to comply. In this case, the units will be sized so as to provide the specified cfm at the reduced rpm.

J. Factory Installed Control Options:
1. No control - Standard. These units shall be operated with automatic controls provided by the control contractor. Factory mounting of control equipment other than Trane must be limited to those items approved by The Trane Company and agreed to by the applicable control vendor. All electric controls within the unit shall be UL listed.
2. Pneumatic: This system will utilize factory furnished and mounted pneumatic controls for operation of the air conditioning units. The unit shall be UL listed. Control packages are available with the following options:
   a. Valve control
   b. Face and bypass control
   c. Night set back
   d. Morning warm up
   e. Low limit thermostat

f. Timed override.

3. Electronic/Analog Control: This system will utilize factory furnished and mounted electronic controls for operation of the air conditioning units. The unit shall be UL listed. The following options are selectable with electronic control:
   a. Valve control
   b. Face and bypass control
   c. Economizer
   d. Night set back
   e. Morning warm up
   f. Low limit thermostat
   g. Mixed air and discharge sensing
   h. Timed override.
4. Direct Digital Control: This system will utilize factory furnished and mounted DDC controls for operation of the air conditioning units. The unit shall be UL listed. The following options are selectable with BAS control:
   a. Valve control
   b. Face and bypass control
   c. Economizer
   d. Night set back
   e. Morning warm up
   f. Low limit thermostat
   g. Mixed air and discharge sensing
   h. Fan, filter status switch
   i. Timed override
   j. Integrated system capability.

K. Other Options:
1. Outdoor Air Inlets:
   a. The unit ventilator manufacturer shall provide wall louvers for outside air intake. They shall be of vertical louver design and equipped with extruded aluminum channels for precise fit.
2. Shelving and Accessories:
   a. Unit ventilator shelving shall be manufactured from 16 gauge cabinet steel and painted in decorator colors as specified by the architect. Shelving shall be equipped with adjustable shelves reinforced with a formed channel for maximum strength. Shelving doors shall be roller hung and equipped with a lock as standard.
   b. Unit ventilator shelving shall be equipped with a decorative and protective aluminum trim strip along the front edge and shall be covered by damage resistant Formica top material (optional).
3. Wall Boxes:
   a. Trane air conditioner wall boxes will provide year around moisture free, outdoor air intake directly to the unit ventilator through the exterior wall. Wall boxes will be available in three standard arrangements to meet installation requirement on virtually any type of building construction.
   b. All Trane wall boxes will be constructed of extremely heavy gauge material and designed to last the life of the building. Internal parts will be interlocked in addition to being held securely in place by the frame-within-a-frame design. This assures proper louver alignment. In addition, the strength of the vertical louver design simplifies installation by eliminating need for a lintel.

L. Manufacturer: Trane, AFF, Daikon, Carrier, or equal. .

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Examine site to verify if site is ready to receive work. Provide layout drawings of air handlers and fan locations to electrical installer.

C. Install air filters in unit during installation phase. Do not operate the unit without filters in place.

D. Install condensate drain piping and traps in accordance with manufacturer's instructions and as shown on the drawings.

E. Install a new set of filters prior to final air balance and substantial completion.

F. Control installers shall install all wiring associated with control signals into the air handlers.

G. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 16 work.

3.2 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours travel from the job site.

END OF SECTION 233415

SECTION 233416

INLINE FANS

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 1, and shall include, but not necessarily be limited to, the following:
   1. Small Cabinet Fans (Ceiling Mounted)
   2. Cabinet Fans (Inline)

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 233113: Air Distribution

D. Division 26: Electrical

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:
   1. Air Movement and Control Association (AMCA):
      a. 99 - Standards Handbook
      b. 210 – Laboratory Methods of Testing Fans for Rating
      c. 300 - Reverberant Room Method for Sound Testing of Fans
      d. 320 - Laboratory Methods of Sound Testing of Fans Using Sound Intensity
      e. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   2. American National Standards Institute (ANSI):
      a. 9 Load Ratings and Fatigue Life for Ball Bearings
      b. 11 Load Ratings and Fatigue Life for Roller Bearings
   3. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
   4. National Fire Protection Association (NFPA):
      a. 70 National electrical Code
      b. 90A Standard for the Installation of Air Conditioning and Ventilating Systems
      c. 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems
   5. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
   6. Underwriters Laboratories, Inc. (UL):
      a. UL 507 Standard for Electric Fan
      b. UL 705 Standard for Power Ventilators
      c. UL 1004: Standard for Rotating Electrical Machines-General Requirements

1.4 SAFETY PROVISIONS

A. Provide all open drives and fan wheels subject to maintenance and potential entanglement with protective guards or screens, with maximum 1/2” openings, meeting OSHA requirements.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, and finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of 1/4” per one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.6 ENVIRONMENTAL REQUIREMENTS

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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect equipment and products against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 GENERAL FAN REQUIREMENTS

A. Construction, Rating and Testing: Provide fans constructed and factory tested in accordance with the Air Moving and Conditioning Association (AMCA). All fan wheels shall be statically and dynamically balanced. Size and capacity as indicated on the Drawings.

B. Motors and Drives: Provide premium efficiency drip-proof motors with temperature rise not greater than 40°C above ambient temperature.
   1. Belt Drive Fans: Provide belt drive assembly capable of 150% of the motor rated horsepower on one less than the total number of belts, for belt drives with two or more belts. All drives shall have adjustable sheaves to allow adjustment of +/-20%. Provide premium efficiency multi-speed motors as indicated on the drawings.
   2. Direct Drive Fans: Provide ECM or premium efficiency motors as indicated on the drawings.

C. Accessories: Provide, as indicated on the drawings and specified in other paragraphs of this Section.

2.2 SMALL CABINET FANS (CEILING MOUNTED)

A. Ceiling mounted exhaust fans:
   1. Manufacturer: Greenheck SP-A, Panasonic, Cook, Penn, Carnes, Twin City, Air King or equal.
   2. General: Provide centrifugal direct drive type ceiling exhaust fan. The fan wheel(s) shall be of the forward curved centrifugal type and dynamically balanced.
   3. Noise Data: Provide sone or octave band noise values at the required air delivery.
   4. Fan Housing: The fan housing shall be constructed of heavy gauge galvanized steel. The housing interior shall be lined with 1/2 inch acoustical insulation, or better. The outlet duct collar shall include a backdraft damper on all sizes and shall be spring loaded on larger units above 200 cfm.
      a. Integral backdraft damper shall be totally chatterproof with no metal-to-metal contact.
      b. Entire fan, motor and wheel assembly shall be easily removable without disturbing the housing.
      c. Outlet shall be adaptable for horizontal or vertical discharge.
   5. Motor speeds shall not exceed 1100 RPM and all fan motors shall be suitably grounded and mounted on rubber-in-shear vibration isolators.
   6. Grille: For 300 cfm and smaller fans the grille shall be constructed of high impact polystyrene and for larger sizes the grille shall be constructed of aluminum. Grilles shall be non-yellowing.
   7. The access for wiring shall be external. The motor disconnect shall be internal and of the plug in type. The motor shall be mounted on vibration isolators.
   8. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance and shall be UL/cUL Listed.

2.3 CABINET FANS

A. Inline Cabinet Fans (Belt Drive and Direct Drive)
   1. Manufacturer: Greenheck #SQ and BSQ Series, Cook, Penn, Carnes, Twin City or equal.

B. Duct mounted supply, exhaust or return fans shall be of the centrifugal, direct drive or belt driven in-line type.

C. Housing: The fan housing shall be of the rectangular design constructed of heavy gauge galvanized steel or aluminum and shall include rectangular duct mounting collars. A hinged or removable panel shall be provided in the fan cabinet of sufficient size to permit access for service to all of the fan's internal components without dismantling the cabinet.

D. The fan wheel shall be of the galvanized steel or aluminum, backward-inclined, centrifugal type. Wheels shall be dynamically and statically balanced. The wheel shaft shall be ground and polished steel mounted in permanently sealed pillow block bearings.

E. Drives shall be sized for a minimum of 150% of driven horsepower. Bearings shall be selected for a minimum L10 life in excess of 100,000 hours at maximum cataloged operating speed.

F. Motors shall be of the heavy-duty type with permanently sealed ball bearings.
   1. Belt drive: Pulleys shall be of the machined cast iron type, keyed and securely attached to the wheel and motor shafts. The motor pulleys shall be adjustable for final system balancing.
   2. Direct drive: Electronically commutated (EC) motor with potentiometer dial mounted on motor for speed adjustment and 0-10 VDC control wire inputs for connecting to the building automation system for remote control.
      a. Up to 3/4 hp: 115 volt
      b. 1 hp: 115/208-230 volt
      c. 2 hp 208-230 volt

G. All fans shall bear the AMCA Certified Ratings Seal for air performance.

H. NEMA-1 disconnect switch to be factory mounted and wired.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate motor starters with Division 26 and controls contractor.

B. Install in accordance with manufacturer's instructions.

C. Examine site to verify if site is ready to receive work. Provide layout drawings of air handlers and fan locations to electrical installer.

D. Install unit on vibration isolators.

E. Install 3" flexible duct connection at inlet and outlet of each unit.

F. Control installers shall install all wiring associated with control signals into the fan starters.

G. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

3.2 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four-hours travel time from the job site.

END OF SECTION 233416

SECTION 238158

VARIABLE REFRIGERANT FLOW HEAT PUMP SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Condensing Units
      a. Air Cooled Condensing Unit – Heat Pump (heat or cool model)
      b. Air Cooled Condensing Unit – Heat Recovery (heat and cool model)
      c. Water Cooled Condensing Unit – Heat Pump/Heat Recovery
   2. Branch Selector (BS) Units or Branch Circuit (BC) Terminal for Heat Recovery systems.
   3. Indoor Fan Coil Units:
      a. Non-ducted Recessed Ceiling Cassette Units
      b. Ducted Concealed Ceiling Fan Coil Units
      c. Ceiling Suspended Unit
      d. Wall Mounted Unit
      e. Floor Console Unit
      f. Floor Console Concealed Unit
      g. Vertical/horizontal Air Handling Unit
   4. 100% OSA Makeup Air Units – 100% OSA Processing Unit
   5. Controls
   6. Refrigerant gas monitors

1.2 SYSTEM DESCRIPTION

A. Heat Recovery (heat and cool model)
   1. The variable capacity heat pump air conditioning system shall be a VRV/VRF series heat and cool model. The system shall consist of multiple evaporators, Branch Selector Units or Branch Circuit Terminals, heat recovery condensing unit with variable speed inverter driven compressors, and PID DDC (direct digital controls). All zones are each capable of operating separately with individual temperature control.
   2. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with each branch of the cool/heat selector box. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller, an Intelligent Controller, an Intelligent Manager or a BAS interface.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230716: Equipment Insulation

D. Section 232300: Refrigerant Piping Systems

E. Section 233113: Air Distribution

F. Division 26: Electrical

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide packaged units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:
   1. Air Movement and Control Association (AMCA):
      a. 99 - Standards Handbook
      b. 210 - Laboratory Methods of Testing Fans for Rating [Unit shall bear AMCA Certified Rating Seal]
      c. 300 - Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal]
      d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
      e. 500 - Test Method for Louvers, Dampers, and Shutters
   2. American National Standards Institute (ANSI):
      a. 9 - Load Ratings and Fatigue Life for Ball Bearings
      b. 11 - Load Ratings and Fatigue Life for Roller Bearings
      c. 900 - Test Performance of Air Filter Units
   3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
      a. 1230 - Variable Refrigerant Flow Multi-Split Air –conditioners and Heat Pumps
   4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
      a. 15 - Safety Code for Mechanical Refrigeration
      b. 193 – Method of Test for Determining the Air Leakage of HVAC Equipment. All systems that move less than 3,000 cfm shall comply with less than 1.4% cabinet leakage rate.
   5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
   6. National Fire Protection Association (NFPA): Provide unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
      a. 70 - National Electrical Code
      b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
      c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems
   7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
   8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of units, which have been listed and labeled by UL. This includes condensate pumps and other ancillary devices required for operation.
   9. Electrical Laboratories (ETL): The units shall be listed by ETL and bear the ETL label.
   10. Minimum Efficiency: Minimum efficiencies shall meet or exceed the values required by the local energy code.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for systems with air handler units, evaporator coils, and outdoor condensing units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals; in accordance with requirements of Division 01.

1.6 ENVIRONMENTAL REQUIREMENTS

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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Store/protect products under provisions of Division 01 and according to manufacturer's recommendation. Protect units against dirt, water, chemical, and mechanical damage. Do not install damaged units - remove from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Provide extended warranty for compressors for a six (6) year period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Daikin VRV III and IV, Mitsubishi City Multi, LG-Multi V, Trane/Samsung Advantage VRF, Fujitsu Airstage VRF, Hitachi, Carrier/Toshiba, or equal.

2.2 CONDENSING UNIT

A. General:
   1. The outdoor unit shall be designed for used with an integrated variable refrigerant flow zone system.
   2. The condensing unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
   3. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
   4. (Heat Recovery Only) Refrigerant lines from the outdoor unit to the BS or BC unit shall be individually insulated between the condensing and fan coil units.
   5. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
   6. The connection ratio of fan coil units to condensing unit shall be permitted up to 150% of outdoor rated capacity.
   7. Each condensing system shall be able to support the connection of up to 50 indoor units dependent on the model of the condensing unit.
   8. The sound pressure level standard shall no greater than 65 dBA at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time.
   9. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
   10. Water-cooled only:

a. Each condensing unit shall have a 240VAC, 0.3mA-0.5A control circuit output for water pump or isolation valve operation. This circuit shall be configured at commissioning to operate based on system or compressor operation.
b. Each condensing unit shall incorporate normally open, 15VDC and 1.0mA rated contacts for integration of a mandatory flow proving device.

11. The unit shall incorporate an auto-charging feature.
12. The condensing unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
13. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
14. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
15. Each system shall maintain continuous heating during oil return operation.
16. The condensing unit shall be capable of heating operation at 0°F dry bulb ambient temperature without additional low ambient controls or an auxiliary heat source.
17. (Heat Recovery only) The system shall continue to provide heat to the indoor units in heating operation while in the defrost mode.

B. Unit Cabinet:
1. Air Cooled: The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
2. Water Cooled: The condensing unit shall be corrosion resistant. The unit shall be constructed from rust-proofed, mild steel panels coated with a baked enamel finish.

C. Fan (air-cooled models only):
1. The condensing unit shall consist of one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG. A field setting switch to a maximum 0.24 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.
3. The fan shall be a vertical discharge configuration.
4. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
5. The fan motor shall be provided with a fan guard to prevent contact with moving parts.
6. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature.

D. Condenser Coil (air-cooled):
1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The fins are to be covered with an anti-corrosion finish.

E. Condenser Heat Exchanger (water-cooled):
1. The condenser heat exchanger shall be a stainless brazed plate type designed for closed loop/dry cooler applications.
2. The heat exchanger shall have a maximum system water pressure of 285 psi (equivalent to 640ft of head).

F. Compressor:

1. The inverter driven scroll hermetic compressors shall be variable speed controlled capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read and calculated. With each reading, the compressor capacity shall be controlled to eliminate deviation from target value.
2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll type
3. The capacity control range shall be as low as 4% to 100%.
4. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
5. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
6. Oil separators shall be standard in the equipment together with an intelligent oil management system.
7. The compressor shall be spring mounted to avoid the transmission of vibration.

G. Electrical:
1. The power supply to the condensing unit shall be as shown on the drawings.
2. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded, stranded 2-conductor cable.
3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one condensing unit with one 2-cable wire, thus simplifying the wiring installation.

2.3 BRANCH SELECTOR (BS) BOX/ BRANCH CIRCUIT (BC) CONTROLLER FOR HEAT RECOVERY SYSTEM

A. General: Branch selector boxes/ Branch circuit controllers are designed specifically for use with heat recovery system components.
1. Selector boxes / circuit controllers shall be factory assembled, wired, piped and run tested at the factory.
2. Selector boxes / circuit controllers must be mounted indoors.
3. When simultaneously heating and cooling, the units in heating mode shall energize their sub-cooling electronic expansion valve.

B. Unit Cabinet:
1. These units shall have a galvanized steel plate casing.
2. Each cabinet shall house multiple electronic expansion valves for refrigerant control per branch.
3. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

C. Refrigerant Valves:
1. The refrigerant connections must be of the braze type.
2. Multiple indoor units may be connected to a branch selector box / branch circuit controller.

D. Condensate Removal:
1. Provide integral condensate pan if required for condensate removal.

E. Electrical:
1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of operation within the limits of 187 volts to 228 volts.
3. The minimum circuit amps (MCA) shall be 0.1 and the maximum
4. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded 2 conductor cable.

2.4 INDOOR FAN COIL UNITS

A. Non-Ducted Recessed Ceiling Cassette Units

1. General: Indoor unit shall be a ceiling cassette fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with an air panel grill. It shall be a four-way air distribution type, white, impact resistant with a washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The indoor units sound pressure shall range from 28 dB(A) to 34 dB(A) at low speed measured at 5 feet below the unit.
2. Indoor Unit:
   a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
   b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
   c. Both refrigerant lines shall be insulated from the outdoor unit.
   d. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
   e. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
   f. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 21” of lift and has a built in safety shutoff and alarm.
   g. The indoor units shall be equipped with a return air thermistor.
3. Unit Cabinet:
   a. The cabinet shall be space saving and shall be located into the ceiling.
   b. Three auto-swing positions shall be available to choose, which include standard, draft prevention and ceiling stain prevention.
   c. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
   d. Fresh air intake shall be possible by way of optional fresh air intake kit. (3’x 3’ model only). Fresh air intake shall be possible by way of direct duct installation to the side of the indoor unit cabinet. (2’x 2 model only’)
   e. A branch duct knockout shall exist for branch ducting supply air.
   f. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
   g. Optional high efficiency MERV 8 and 13 air filters are available for each model unit. (3’ x 3’ model only)
4. Fan:
   a. The fan shall be direct-drive fan type with statically and dynamically balanced impeller with high and low fan speeds available.
   b. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range from 0.06 to 0.12 HP.
   c. The airflow rate shall be available in high and low settings.
   d. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings to allow operation with the MERV 8 and 13 filter options (3’x 3’ model only).
   e. The fan motor shall be thermally protected.
5. Filter:
   a. The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

b. Optional high efficiency disposable MERV 8 and 13 filters shall be available. (3' x 3' model only)

6. Coil:
   a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
   b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
   c. The coil shall be a 2-row cross fin copper evaporator coil completely factory tested.
   d. The refrigerant connections shall be flare connections.
   e. A condensate pan shall be located under the coil.
   f. A condensate pump, with minimum 21-inch lift, shall be located below the coil in the condensate pan with a built in safety alarm.
   g. A thermistor will be located on the liquid and gas line.
7. Electrical:
   a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
   b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
   c. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
8. Control:
   a. The unit shall have on board controls to perform input functions necessary to operate the system.
   b. The unit shall include all devices necessary to be compatible with interfacing with a BAS system via optional LonWorks or BACnet gateways.
9. Optional Accessories Available:
   a. A high efficiency disposable MERV 8 air filter kit. (3' x 3')
   b. A high efficiency disposable MERV 13 air filter kit. (3' x 3')
   c. Fresh air intake kit.
   d. Supply air branch duct connections.
   e. Remote "in-room" sensor kit.
   f. The wall mounted, hard wired remote sensor kit is recommended for ceiling-embedded type fan coils, which often result in a difference between set temperature and actual temperature. The sensor for detecting the temperature can be placed away from the indoor unit (branch wiring is included in the kit).

B. Ducted Concealed Ceiling Fan Coil Units
1. General:
   a. Indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation in a ceiling cavity. It is constructed of a galvanized steel casing. It shall be a horizontal discharge air with horizontal return air configuration. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. Included as standard equipment, a condensate drain pan and drain pump kit that pumps up to 18-3/8" from the drain pipe opening.
   b. All pressure drops, horsepowers and dimensions shown on drawing schedules are maximum allowable. All capacities shown are minimum allowable. All units must have AMCA certified performance data for fans tested in the unit casings. Bare fan certification without casing is not acceptable.
   c. Manufacturers unable to meet these criteria will only be considered as an alternate to specified and as a deduct to base bid. Manufacturers listed by name does not imply that their standard construction meets the specifications nor that they are approved. All manufacturers are required to meet all details of this specification without exception.
2. Sound Pressure Level:

a. Large capacity, medium static units: 48 dB(A) at low speed measured 5 feet below the ducted unit.
b. Small capacity, medium static units: 29 dB(A) to 40 dB(A) at low speed measured 5 feet below the ducted unit.
c. Shallow depth fan coils: 29 dB(A) to 32 dB(A) at low speed and 33 dB(A) to 36 dB(A) at high speed 5 feet below the suction grille.

3. Indoor Unit: The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an adjustable external static pressure switch (Large models). The unit shall be equipped with automatically adjusting external static pressure logic selectable during commissioning. This adjusts the airflow based on the installed external static pressure. (Small models)
   a. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
   b. Both refrigerant lines shall be insulated from the outdoor unit.
   c. The indoor units shall be equipped with a return air thermistor.
   d. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 18-3/8” of lift from the center of the drain outlet (Small and slim model only)
   e. Return air shall be through a resin net mold resistant filter (slim model only)
4. Unit Cabinet:
   a. The cabinet shall be located within the ceiling and ducted to the supply and return openings.
   b. The cabinet shall be constructed with minimum 1/2” 1.5 lbs. internal insulation. Insulation shall be attached with adhesive with all exposed edges coated to prevent erosion or of an insulation type not requiring protection.
5. Fan:
   a. (Large models and slim duct):
      1) The fan shall be direct-drive type fan, statically and dynamically balanced impeller with high and low fan speeds available.
      2) The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz, with a motor output of 0.51 HP.
      3) The airflow rate shall be available in high and low settings.
      4) The fan motor shall be thermally protected.
      5) The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.
   b. Fan (Small models):
      1) The fan shall be direct-drive DC (ECM) type fan, statically and dynamically balanced impeller with three fan speeds available.
      2) The unit shall be equipment with automatically adjusting external static pressure logic selectable during commissioning.
      3) The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range of 0.12 to 0.47 HP respectively.
      4) The airflow rate shall be available in three settings.
      5) The fan motor shall be thermally protected.
      6) The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.
6. Coil:
   a. Coils shall be ARI certified of the direct expansion type.
   b. All coil casings shall be galvanized steel minimum or stainless steel.
   c. Copper tubes shall be a minimum thickness of 0.020 and return bends of minimum 0.035. Headers shall be non-ferrous seamless copper. Aluminum fins shall have a minimum thickness of 0.0080 and tubes shall be mechanically expanded into fin collars to provide permanent mechanical bond.

d. The coils shall be pressure tested at the factory.
e. The refrigerant connections shall be flare connections.
f. A thermistor will be located on the liquid and gas line.
g. A condensate pan shall be located under the coil
h. The condensate shall be capable of being gravity drained from the fan coil.
i. Where scheduled, a condensate pump with an 18" minimum lift shall be located below the coil in the condensate pan with a built in safety alarm.

7. Electrical:
   a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
   b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
   c. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
8. Control:
   a. The unit shall have on board controls to perform input functions necessary to operate the system.
   b. The unit shall include all devices necessary to be compatible with interfacing with a BAS system via optional LonWorks or BACnet gateways.
9. Optional Accessories Available:
   a. Remote "in-room" sensor kit (recommended).
   b. The wall mounted, hard wired remote sensor kit is recommended for ceiling-embedded type fan coils, which often result in a difference between set temperature and actual temperature. The sensor for detecting the temperature can be placed away from the indoor unit (branch wiring is included in the kit).

C. Non-Ducted Wall or Ceiling Fan Coil Units
1. General: Indoor unit shall be a fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation onto a wall or ceiling within a conditioned space. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition.
2. Condensate drain pan:
   a. Ceiling Suspended Cassette Unit: A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment.
   b. Wall Mounted Unit: A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment.
   c. Floor Console Unit: A mold-resistant, resin net air filter shall be included as standard equipment.
3. Sound Pressure:
   a. Ceiling Suspended Cassette Unit: The indoor units sound pressure shall range from 32 dB(A) to 38 dB(A) at low speed measured at 3.3 feet below and from the unit.
   b. Wall Mounted Unit: The indoor units sound pressure shall range from 31 dB(A) to 40 dB(A) at low speed measured at 3.3 feet below and from the unit.
   c. Floor Console Units (Surface mount and concealed types): The indoor units sound pressure shall range from 35 dB(A) to 40 dB(A) at high speed measured at 5 feet away and 5 feet high.
4. Indoor Unit:
   a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops
   b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.

c. Both refrigerant lines shall be insulated from the outdoor unit.
d. Return air shall be through a resin net mold resistant filter.
e. The indoor units shall be equipped with a condensate pan.
f. The indoor units shall be equipped with a return air thermistor.

5. Unit Cabinet:
   a. The cabinet shall be affixed to a factory supplied wall/ceiling hanging brackets and located in the conditioned space.
   b. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
6. Fan:
   a. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
   b. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz.
   c. The airflow rate shall be available in high and low settings.
   d. The fan motor shall be thermally protected.
7. Filter:
   a. The return air shall be filtered by means of a washable long-life filter with mildew proof resin (Floor console only).
8. Coil:
   a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
   b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
   c. The coil shall be a 2-row (3-row floor console only) cross fin copper evaporator coil completely factory tested.
   d. The refrigerant connections shall be flare connections.
   e. A thermistor will be located on the liquid and gas line.
   f. A condensate pan shall be located in the unit.
9. Electrical:
   a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
   b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
   c. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
10. Control:
    a. The unit shall have on board controls perform input functions necessary to operate the system.
    b. The unit shall include all devices necessary to be compatible with interfacing with a BAS system via optional LonWorks or BACnet gateways.
11. Optional Accessories Available:
    a. Remote “in-room” sensor kit.
    b. A condensate pump.

D. Floor Mounted Fan Coil Unit
1. General: The indoor unit shall be a floor mounted vertical or horizontal air handling unit, operable with refrigerant R-410A, equipped with an electronic expansion valve and direct-drive ECM type fan with auto CFM adjustment, for installation within a conditioned space. When installed in a vertical configuration it shall have top discharge air and bottom return air. When installed in a horizontal right configuration it shall have a horizontal discharge air and horizontal return air. Cabinet shall be pre-painted heavy-gauge steel. A remote temperature sensor kit shall be required for all indoor units not utilizing the thermistor in the remote controller. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature.

2. Indoor Unit:
   a. The indoor unit components shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, brazed connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
   b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
   c. Both refrigerant lines shall be insulated from the outdoor unit.
   d. Return air shall be through an optional or field supplied filter.
   e. Condensate draining shall be made via gravity or external condensate pump.
3. Unit Cabinet:
   a. The cabinet shall be constructed with sound absorbing, foil-faced insulation to control air leakage.
   b. Select an installation location with adequate structural support, space for service access and clearance for air return and supply duct connections.
   c. A field supplied secondary drain pan must be installed
4. Fan:
   a. The fan shall be a direct-drive type fan, statically and dynamically balanced impeller with high and low fan speeds available.
   b. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range 0.2 to 0.5 HP.
   c. The airflow rate shall be available in high setting.
   d. The fan motor shall be thermally protected.
5. Filter:
   a. The return air shall be filtered by means of a field supplied filter.
   b. Coil:
   c. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
   d. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
   e. The coil shall be a 4-row cross fin copper evaporator coil completely factory tested.
   f. The refrigerant connections shall be brazed connections and the condensate will be 3/4 inch outside diameter PVC.
   g. A thermistor will be located on the liquid and gas line.
6. Electrical:
   a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
   b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
   c. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
7. Control:
   a. The unit shall have onboard controls provided to perform input functions necessary to operate the system.
   b. The unit shall include all devices necessary to be compatible with interfacing with a BAS system via optional LonWorks or BACnet gateways.
8. Optional Accessories Available:
   a. Field installed 3-20kW electric heaters. The indoor units shall have circuit breakers supplied with each electric heat kit.
   b. Air filter.
   c. Insulation kit for vertical and horizontal configurations.
   d. Wireless controller.

E. 100% Makeup Air Unit

1. General: Indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation into the ceiling cavity. The unit shall be capable of introducing up to 100% outside air controlled to a fixed discharge air temperature. It is constructed of a galvanized steel casing. It shall be a horizontal discharge air with horizontal return air configuration. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The indoor units sound pressure shall range from 42 dB(A) to 47 dB(A) at low speed measured 5 feet below the ducted unit.
2. Indoor Unit:
    a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay and test run switch.
    b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
    c. Both refrigerant lines shall be insulated from the outdoor unit.
    d. The indoor units shall be equipped with a discharge air thermistor.
3. Unit Cabinet:
    a. The cabinet shall be located into the ceiling and ducted to the supply and return openings.
    b. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
4. Fan:
    a. The fan shall be direct-drive type fan, statically and dynamically balanced impeller with high and low fan speeds available.
    b. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz, with a motor output of 0.51 HP.
    c. The fan motor shall be thermally protected.
5. Coil:
    a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
    b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
    c. The coil shall be a 3 row cross fin copper evaporator coil completely factory tested.
    d. The refrigerant connections shall be flare connections
    e. A thermistor will be located on the liquid and gas line.
6. Electrical:
    a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
    b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
    c. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.
7. Control:
    a. The unit shall have onboard controls to perform input functions necessary to operate the system.
    b. The unit shall include all devices necessary to be compatible with interfacing with a BAS system via optional LonWorks or BACnet gateways.

2.5 CONTROLS

A. General:
    1. Provide control devices necessary to support a fully operating system including but not limited to
        a. Local remote controllers,

b. Centralized/multi-zone controllers,
c. Open protocol network devices that transmit information via the communication bus and graphical user workstations.

2. The network shall have the capability to support
   a. Operation monitoring and scheduling,
   b. Error email distribution
   c. General user software, tenant billing, maintenance support, and integration with Building Automation Systems (BAS) using open protocol via BACnet or Lonworks interfaces.
3. General Electrical Requirements: The control wiring shall be terminated in a daisy chain design at the outdoor unit, which is then daisy chained to the branch circuit selector/controller (Heat Recovery System), then daisy chained to each indoor unit in the system and terminating at the farthest indoor unit. Wiring shall be non-shielded, 2-conductor sheathed vinyl core or cable, AWG stranded copper wire installed per manufacturer's written instructions.

B. Local Remote Controllers
1. The local remote controllers shall be capable of controlling up to 16 indoor units (referred to as a group). The local remote controllers shall maintain the optimal operation of the connected indoor units. Local remote controllers consist of deluxe, simplified and wireless models. No more than two of these controllers can be placed in the same group. No addressing shall be required with the local remote controllers.
2. Basic Operation: Local remote controller shall control the following group of operations:
   a. On/off, operation mode (cool, heat, fan, dry and Auto)
   b. Independent cooling and heating setpoints in the occupied mode
   c. Independent cooling setup and heating setback setpoint in the unoccupied mode.
   d. Fan speed
   e. Airflow direction
   f. The controller shall be able to limit the user adjustable setpoint ranges individually for cooling and heating in the occupied period
   g. Function key lockout
3. Programmability:
   a. Controller shall support 7-day programmable scheduling,
   b. The controller shall support auto-changeover mode for both heat pump and heat recovery systems allowing the optimal room temperature to be maintained by automatically switching the indoors unit's mode between cool and heat according to the room temperature and temperature setpoint.
   c. The controller shall support an auto off timer for temporarily enabling indoor unit operation using unoccupied period.
   d. The room temperature shall be capable of being sensed at either, the remote controller, the indoor unit return air temperature sensor (default), or a remote temperature sensor.
4. Display Features
   a. LED display
   b. The controller shall display Operations Mode, Setpoint, and Fan Speed.
   c. System Status icons in large font.
   d. Room temperature display
   e. On/Off status
   f. Error codes displayed in the event of a system abnormality/error
   g. Optional: The following system temperatures can be displayed to assist service personnel in troubleshooting:
      1) Return air temperature
      2) Liquid line temperature
      3) Gas line Temperature
      4) Discharge Air Temperature (depending on fan coil)
      5) Temperature used for indoor unit control.

C. Centralized/Multizone Controllers

a. The Centralized/Multizone controllers shall be capable of controlling up to 64 indoor unit groups and 128 indoor units connected to up to 10 outdoor units The Centralized/Multizone Controllers shall be complete with power supply. The Centralized/Multizone Controllers can be used in conjunction with local remote controllers, BACnet and Lonworks interfaces to control the same indoor unit groups. Centralized/Multizone controllers shall be available with the option of interconnection with a network PC via the internet or Local Area Network (LAN).

b. Basic Operation: The Centralized/Multizone controller shall control the following group operations:

1) On/off, operation mode (cool, heat, fan, dry and Auto)
2) Independent cooling and heating setpoints in the occupied mode
3) Independent cooling setup and heating setback setpoint in the unoccupied mode.
4) Fan speed
5) Airflow direction
6) The controller shall be able to limit the user adjustable setpoint ranges individually for cooling and heating in the occupied period
7) Remote controller permit/prohibit of ON/Off, Mode, and Setpoint.
8) Lockout setting for touch display.
9) Indoor unit Group/Zone assignment.

2. Programmability:

a. Controller shall support weekly schedule settings.
b. Scheduling shall support unit On/Off.
c. The controller shall support multiple auto-changeover methods for both Heat Pump and Heat Recovery systems based upon the Zone configurations. This will allow for the optimal room temperature to be maintained by automatically switching the indoors unit's mode between cool and heat according to the room temperature and temperature setpoint.
d. Controller shall support Interlock for use with 3rd party equipment to automatically control groups or zones corresponding to the change of the operation states or On/Off states of any group.
e. Optional Digital Input/Output unit shall be available to allow On/Off based monitoring and control of 3rd party equipment.
f. The controller shall support force shutdown of associated indoor unit.

3. Display Features:

a. Backlit LCD display.
b. Multi-language availability.
c. The controller shall display On/Off, Operations Mode, Setpoint, space Temperature, Louver Position, Fan Speed for Group/Zone.
d. Date, day of week and time of day.
e. Daylight savings automatic adjustment.
f. Display update every 3 seconds.
g. System status icons shall display On/Off (color coded), Malfunction/Error (color coded), Forced Stop, Set Schedule/Setback/Auto-changeover, Filter, and Screen Lock.
h. The controller shall display the temperature setpoint in one degree increments.
i. Zone configuration shall display Setpoint Range Limitation, Setback Temperature setting, and Auto-changeover for each Zone.
j. Indoor units shall be capable of being displayed by Zone or Group.
k. Error status shall be displayed in the event of system abnormality/error with one of two color coded icons placed over the indoor unit icon.

4. Software Options: All PC's shall be field supplied

a. Web/Email software: Each Controller shall be capable of monitoring, operating, and scheduling a maximum of 64 indoor unit groups (128 indoor unit groups with the addition of an option adapter) from a networked PC's web browser. It shall also be capable of

creating general user access and sending detailed error emails to a customized distribution list (up to 3 email addresses).

b. Power Proportional Distribution (PPD): The tenant billing option shall be capable of calculating VRV Controls Network equipment energy usage in kWh based on the energy consumption of the outdoor unit(s) divided among the associated indoor units. This software is used in conjunction with the Watt Hour Meter (WHM). A maximum of 3 Watt Hour Meters can be connected to the Controller. The use of the optional adapter will add an additional 3 Watt Hour Meters.

c. HTTP Interface: This option shall be capable of creating a software interface between the VRV Controls Network and Home Automation control systems.

D. System BAS Integration

1. The VRV/VRF system shall support integration with Building Management Systems (BAS) via a BACnet® or LonWorks interface.
2. BAS to have capability to monitor and control of VRV indoor units.
3. The VRV/VRF systems supplier shall cooperate fully with BAS supplier to enable them to map points into the BAS.
4. The BAS supplier shall provide all labor and programming necessary to map VRF system points into BAS. At a minimum, through the BAS, the operator shall be enabled to monitor space temperature of all zones change space temperature setpoint of all zones, monitor fan, heating and cooling status of all zones, monitor indoor fan coil alarm, monitor status and alarms of outdoor units and schedule each zone.
5. Operation and monitoring points include but are not limited to:
   a. On/Off (setting)
   b. On/Off (status)
   c. Alarm Sign
   d. Error Code
   e. Operation Mode (setting)
   f. Operation Mode (status)
   g. Fan Speed (setting)
   h. Fan Speed (status)
   i. Measured Room Temperature
   j. Set Room Temperature
   k. Filter Limit Sign
   l. Filter Limit sign reset
   m. Remote Control Operation (On/Off)
   n. Remote control Operation (Operation Mode).
   o. Remote Control Operation (Set Temperature)
   p. Electrical Total Power
   q. Communication Status
   r. System Forced Off
   s. Forced Thermostat off (setting)
   t. Forced Thermostat off (status)
   u. Compressor Status
   v. Indoor Fan Status
   w. Heater operation Status

2.6 REFRIGERANT GAS MONITOR

A. Where indicated on drawings provide a standalone refrigerant gas monitor and sensor to monitor and alarm for refrigerant gas leaks in the space.

B. Sensor to be coordinated with the refrigerant used in the VRF or VRV system and mounted remotely from unit at the level of the floor in the indicated space.

C. Alarm to be a red LED and siren with mute button. Relays are to be provided for remote monitoring or control.

2.7 ISOLATION VALVE

A. Bi-directional full-port full-flow manual service valve with refrigerant Schrader valve.

B. Brass body with flared extended copper tails for brazing. Indicator on stem shows valve position-open or closed with quarter-turn of the valve stem. Blow-out proof stem design with cap seal and solid cap.

C. Operating pressure: 0 to 700 psig (4.8 MPa/48 bar).

D. Temperature range: -40°F to 300°F (-40°C to 150°C).

E. Manufacturers: Henry Group #937613, Wilspec #Frontline Series, or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that mounting surfaces are ready to receive work.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide layout drawings of units, locations and power requirements to electrical installer.

C. Install air filters in unit during installation phase. Do not operate the unit without filters in place.

D. In the case of suspended units, mount the fan coil units on springs or from spring hangers as required and as shown on Drawings. Provide Mason #DNHS combination isolator hangers to fully support horizontal units hung from building framing.

E. Provide 4" high concrete pad extending 6" beyond edge of condensing unit on all sides. Attach condensing unit to concrete pad with concrete anchors and angle brackets.

F. Install 2" flexible duct connection at inlets and outlets of ducted units.

G. Install condensate drain piping and traps in accordance with manufacturer's instructions and as shown on the Drawings. Where drainage to gravity waste is not possible provide condensate pumps.

H. Install copper refrigerant piping and insulate lines.

I. Install branch isolation valve at each fan coil and branch refrigerant selector to allow for future maintenance refrigerant recovery without the need to recover entire system charge. Valves must be full port with Schrader valve on the fan coil or branch selector side of valve. Provide quantity of valves as required to provide complete isolation of each unit. Each fan coil will require a minimum of two valves for each circuit and each branch selector may require a minimum of three valves for each circuit, and as required to serve the quantity of refrigerant circuits. Coordinate with manufacturer’s installation instructions for placement of valves for full isolation and to avoid warranty violation.

J. Control wiring: Communication wiring shall be terminated in a daisy chain design at the outdoor unit, which is then daisy chained to branch selector/controller (Heat Recovery system), then daisy chained to each indoor unit in the system and terminating at the farthest indoor unit. The termination of the

wiring shall be non-polar. The remote control wiring shall run from the indoor unit control terminal block to the remote controller connected with that indoor unit. Wiring shall be non-shielded, 2-conductor sheathed vinyl cord or cable, AWG stranded copper installed per manufacturer's written directions.

K. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

L. Install a new set of air filters prior to final air balance and substantial completion.

M. Provide support to BAS supplier for mapping of VRV/VRF systems points into the BAS.

3.3 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours travel from the job site.

END OF SECTION 238158

SECTION 238219

FAN COIL UNITS

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 1, and shall include, but not necessarily be limited to, the following:
   1. Fan Coils.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230593: Testing, Adjusting and Balancing.

C. Section 230900: Building Automation System (BAS) Controls.

D. Section 230716: Equipment Insulation.

E. Section232113: Hydronic Piping, Valves and Specialties.

F. Section 233113: Air Distribution.

G. Division 26: Electrical.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430, "Central-Station Air Handling Units."

C. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:
   1. Air Movement and Control Association (AMCA)/American National Standards Institute (ANSI):
      a. 99: Standards Handbook.
      b. 210: Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating [Unit shall bear AMCA Certified Rating Seal].
      c. 230: Laboratory Methods of Testing Air Circulating Fans for Rating and Certification.
      d. 300: Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal].
      e. 301: Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
      f. 500-D: Laboratory Methods of Testing Dampers for Rating.
   2. American National Standards Institute (ANSI)/Anti-Friction Bearing Manufacturers Association (ABMA):
      a. 9: Load Ratings and Fatigue Life for Ball Bearings.
      b. 11: Load Ratings and Fatigue Life for Roller Bearings.
      c. 900: Test Performance of Air Filter Units.
   3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
      a. 410: Forced-Circulation Air-Cooling and Air-Heating Coils.
      b. 430: Central-Station Air-Handling Units.
   4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

a. 193: Method of Test for Determining the Air Tightness of HVAC Equipment. All systems that move less than 3,000 cfm shall comply with less than 1.4% cabinet leakage rate.

5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
1. ANSI/AHRI-850: Performance Rating of Commercial and Industrial Air Filter Equipment.
7. Underwriters Laboratories, Inc. (UL), Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL:
   a. 900: Standard for Air Filter Units.
8. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. 70 - National Electrical Code.
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, and finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of one half inch to one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.5 ENVIRONMENTAL REQUIREMENTS

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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect unit against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.7 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 FAN COIL UNIT – FOR COMMERCIAL APPLICATION

A. Manufacturers:
1. Enviro-Tec, Carrier, Trane, Temtrol, Huntair, Nailor, Miller-Picking, Buffalo, Energy Labs, Haakon Industries, Air Enterprises, International Environmental Corp (IEC), Nailor, or equal.

B. General:
1. Factory fabricated fan coil units of the size, type configuration and capacity as scheduled on the drawings.
2. All pressure drops, motor horsepowers and dimensions shown are maximum allowable. All capacities shown are minimum allowable. All units must have AMCA certified performance data for fans tested in the unit casings. Bare fan certification without casing is not acceptable.
3. Manufacturers unable to meet these criteria will only be considered as an alternate to the specified unit and as a deduct to the base bid. Manufacturer listed by name does not imply that their standard construction meets the specifications nor that they are approved. All manufacturers are required to meet all details of this specification without exception.

C. Unit Casing:
1. Unit shall be constructed of no less than 16 gauge formed cold-rolled steel with minimum 1" 1.5 lb. density internal insulation. Insulation shall be attached with adhesive with all exposed edges coated to prevent erosion. All exposed metal inside and out shall be finished with at least one coat of gray enamel. Bottom access doors shall be aluminum construction 0.063 thickness painted to match unit.

D. Fan Assembly:
1. Bearings shall be ball or roller type. Sleeve bearings are not acceptable. Bearings shall have replaceable inserts so entire housing need not be replaced. Bearings shall be self-aligning to assist in shaft alignment. Self-locking collars shall be proved to secure bearing to the shaft. Bearing housing shall be cast iron for strength and long life. Each bearing shall have pressure relief fittings to assure bearing seal life. Bearing life shall be minimum L-10 100,000 hour. Calculations shall be made on the basis of load ratings based on the AFBMA "Method of evaluating load ratings for ball bearings", and are the steady, radial loads that bearings can endure at various speeds for 1,500 hours with 90% of the group surviving. Calculations shall be submitted for engineer review upon request. Bearing operation shall be checked under load at the design speed. Bearing pass/fail criteria shall be based on 1987 ASHRAE Handbook, chapter 52, table 26.
2. Rotating assembly shall be steel channel type construction to provide rigid support for motor, drive, bearings, shaft and wheel. Entire assembly to be mounted on open coil type springs with seismic restraint. Assembly shall have bottom access and entire assembly shall swing down for maintenance. Assembly shall also be completely removable without disassembling unit casing.
3. Shafting shall be carbon steel, turned, ground and polished to close tolerance and oversized to insure vibration free operation. Shafts shall be selected not to exceed 75% of first critical speed. Shaft shall be cleaned and coated to protect against condensation and/or airborne contamination. The cleaning procedure shall include removing any surface rust, loose mill scale, weld spattering and sharp prominences by scraping, sanding and wire brushing to the degree specified by SSPC-SP-1 & 2. The removal of all oil, grease, dirt, salts, soil and contaminants shall be accomplished by cleaning with solvent. After cleaning, shaft shall be coated all over exposed surfaces with a lacquer based shaft protectant. Bluing pigment shall be added to facilitate visual conformation of total coverage. Removal of coating for wheel and hub service shall be achieved with the use of only a lacquer thinner.
4. Fans may be direct drive or belt drive as shown on the drawings. Belt drive units shall utilize a V-belt with cast iron sheaves. Motor sheaves shall be of the adjustable pitch diameter type. Drives shall be rated at no less than 150% of nameplate horsepower.

5. Motors shall be standard NEMA frame type. All motors shall be premium efficiency type. No others are acceptable.
6. Fractional horsepower motors to be resilient mounted and integral horsepower motors to be rigid mounted to spring isolated rotating assembly frame. Power leads from motors to be field installed with flex connection to field supplied junction box allowing enough length for rotating assembly swing down.

E. Coils:
1. Coils shall be ARI certified and of the same manufacturer as the unit to insure proper fit and quality. All coil casings shall be 16-gauge galvanized steel minimum or stainless steel. Copper tubes shall be minimum 5/8" diameter with a minimum thickness of 0.020 and return bends of minimum 0.035. Headers shall be non-ferrous seamless copper. Aluminum fins shall have a minimum thickness of 0.0080 and tubes shall be mechanically expanded into fin collars to provide permanent mechanical bond. No exposed copper shall show between fins.
2. Coils shall be mounted in stainless steel drain pans.

F. Filter Section:
1. Filters shall be minimum MERV-8 efficiency and velocity shall be less than 500 FPM.
2. Filter access is bottom removal unless shown otherwise on plans and schedule.

G. Unit Suspension:
1. Manufacturer to provide factory welded mounting clips for suspension of units. Clips to be capable of accepting 1/2" rod or isolators. Weights shown on plans are maximum allowable operating weights including water in coils.

H. Side Access:
1. Where shown on plans provide side access to unit components. Access panel is to be hinged and large enough to provide full access to internal components. Door latch to be CAD plated spring steel manual quick release "Ludwig" latch with pressure closure mechanism. Door to be painted galvanized 16-gauge steel with pin break edge reinforcement. Door to be sealed on all four edges with gasket adhesively attached to the door panel.

2.2 RECESSED, SEMI-RECESSED, OR FLOOR STANDING FAN COIL UNITS

A. General:
1. System Description: Hydronic heating and cooling device in the recessed (built-in), semi-recessed (with front panel), wall (flush mounted with powder coated casing), or floor mounted (with load bearing grille).
2. Manufacturer: Jaga BRIZA, Kampmann Venkon, or equal.

B. Quality Assurance:
1. The water source heating and cooling equipment shall be certified for outputs based on EN442 standards
2. Each Units shall be fully tested at the factory.
3. Insulation and adhesives shall meet NFPA-90A requirements for flame spread and smoke generation
4. All aluminum components shall be certified to meet ASTM G53 UV-resistance
5. Surface temperature remains safe at all times based on DHSS DN 4 1992 regulation and subsequent revision.
6. All units shall be individually packaged and labeled for eased on site locating and installation

C. Mechanical Parts:
1. Cabinets for wall or ceiling mounting
   a. The cabinet shall be fabricated with 16-gauge electrolytic galvanized steel and will be coated epoxy polyester baked at 392°F. Available in light grey metallic lacquer.
   b. The top or front grille shall provide supply air. The bottom or front bottom shall provide return.

c. The cabinet front face shall be constructed of a single uniform piece seamless in construction.
d. The cabinet shall be fabricated with heat exchanger support bracket. Standard configuration will be center mounted.
e. All valve connections shall be made inside of the cabinet unless separate enclosures are supplied.
f. The cabinet shall be fabricated such that there are no exposed corners or gaps. All corners shall be joined to form one solid piece – gaps are not permitted.
g. The unit shall come with locate and fasten support structure.
h. The cabinet shall be factory parts warranted for 10 years.
i. Color coordinated with architectural where exposed.

2. Heat Exchanger
a. The heat exchanger shall be of copper and aluminum construction. Shall be composed of round, seamless circulation tubes pure red copper, and two brass collectors.
b. The fins shall be connected to the heat exchanger by expansion method only.
c. The heat exchanger shall be factory pressure tested to 300 psi, working pressure rated to 150 psi.
d. The heat exchanger shall have ASTM G53 certification.
e. Heating and cooling by hydronic coils as scheduled for 4-pipe and 2-pipe applications.
f. Each individual heat exchanger shall have EN442 certification. Output Correction factors will not be considered equivalent to establish output capacities.
g. Each heat exchanger shall be of ultra-low thermal inertia in design.
h. The heat exchanger fins shall be corrugated by design.
i. The heat exchanger shall be factory parts warranted for 30 years.

3. The support frame:
a. Pre-assembled heating and cooling unit for recessed fitting into the wall consisting of 19-gauge (or thicker) galvanized steel sheet.
b. Possible to achieve a minimum recess depth of 4.9".
c. The unit is equipped with a PVC condensation collecting tray and drain.
d. Insulation to avoid the formation of condensation and to reduce the noise.

D. Electrical Parts:
1. The fan motor shall be electronically commutated, brushless DC with ball bearings and provide 100% variable operation.
2. The fan motors shall be 24 VDC, low voltage. Optional 24 VAC fan connection.
3. The fan system shall maintain sound noise pressure levels below 36 dBA at all times.
4. The fan speed can be completely modulated.
5. ECM fans warranted for standard 2 years (minimum).
6. ECM fans include 0-10 V analog controls.

2.3 FAN COIL UNITS – RESIDENTIAL FOR MULTIFAMILY APPLICATION

A. Performance Data:
1. Capacity: Unit capacities certified under AHRI 440 Performance Rating of Room Fan-Coils.

B. Construction:
1. Vertical Basic Units: Basic unit includes chassis, coil, heavy density, faced glass fiber insulation, air block-offs around coil, removable fan board/drain pan assembly, auxiliary drain pan, fan(s), fan housing(s), motor and filter. Chassis of galvanized steel with flanged edges. Auxiliary drain pan of molded, high impact, flame resistant, ABS thermoplastic with solderless connection (7/8" OD copper tubes of 1" OD ABS plastic pipe) - 02-06; 18-gauge galvanized steel with Polyurethane insulation on underside and 7/8" OD copper sweat drain connection.
2. Vertical Cabinets: 18-gauge steel panels (minimum). Front and end panels have channel formed edges around entire perimeter. Front panels have faced, heavy density thermal and

acoustical insulation over entire coil section. Front and end panels removable. Recessed stamped integral discharge grille or adjustable 4-way grilles. Optional cam lock access door.

3. Horizontal Basic Unit: Basic units shall include coil, sleeved coil end supports, main drain pan, fan board, fan(s), fan housing(s), motor and thermal insulation.
4. Horizontal Cabinet: 18-gauge steel with channel formed panel edges. Hinged, bottom access panel held closed by cam lock fasteners. Stamped integral discharge grilles on front of cabinet or adjustable cast aluminum 4-way grilles. All discharge angles 15 degrees from horizontal.
5. Horizontal Recessed: Bottom panel shall be 18-gauge steel (minimum) and removable. Panel may be hinged at back and cam locked at front for access.
6. Cabinet Finish: All cabinet parts are cleaned, bonderized, phosphatized, and painted with light gray baked-on enamel finish as standard. Exposed cabinet color shall be selected to match adjacent architectural surfaces.
7. Coils:
   a. All water coils are burst tested at 450 psig (air) and leak tested at 300 psig (air underwater).
   b. Maximum main coil working pressure is 300 psig. Maximum entering water temperature is 275°F. Tubes and U-bends are 5/8" OD copper. Connections are expanded to access standard 5/8" OD copper tubing.
   c. Maximum auxiliary coil (L) working pressure is 200 psig. Maximum entering water temperature is 220°F. Tubes are 7/16" OD copper. Connections are expanded to accept standard 1/2" OD copper tubing.
8. Piping Packages:
   a. All piping packages are burst tested at 450 psig (air) and leak tested at 300 psig (air underwater). The piping packages maximum working pressure is 300 psig. The maximum entering water temperature on the electric water valves is 200°F.
   b. When using two way valves, some means, such as a pump and chiller bypass, must be provided to ensure the maximum water pressure drop rating of the two-way valve is not exceeded. These valves are rated for a maximum pressure differential across the valve of 25 psig.
9. Drain Pans: Horizontal and vertical main drain pans galvanized steel with flame resistant polystyrene foam insulation liner.
10. Fans: Fan wheels shall be centrifugal forward curved and double width. Fan wheels and housings corrosion resistant. Fan housings of formed sheet metal.
11. Motors:
    a. All motors have integral thermal overload protection. Motors operate satisfactorily at 90% of rated voltage on all speed settings and at 10% overvoltage without undue magnetic noise.
    b. All motors factory run tested in assembled unit prior to shipping.
    c. Motor cords quickly detachable at switch box by locking pronged connector (optional on horizontal units).
12. Filters: Concealed from sight and removable from vertical models without displacing front panels. Throwaway type of woven glass fiber.
13. Dampers and Damper Operators (vertical models only):
    a. Damper blades 18-gauge steel, factory adjusted to close against polyurethane stop across entire blade length. Dampers available on 25% manual, 25% with operator and 100% proportional.
    b. Factory mounted electric operators run tested through full stroke with factory check of sealing.

C. Manufacturers: Trane, International Fan Coil, York, AFF, Daikin, Airtherm, Krueger, Rittling, Carrier, or equal.

2.4 PROGRAMMABLE THERMOSTAT

A. Thermostat with 365-day programmability that allows the building occupants to program the temperature setpoints for at least four periods within 24 hours. A minimum of 5 holidays shall be programmable for up to 5 years. Daylight savings shall be provided as a standard feature in the programming calendar.
   1. Manufacturers: Honeywell VisionPRO 8000 Series, Honeywell Prestige THX 9000 Series, Honeywell TB7600 Series, Venstar ColorTouch T6000 Series, EnTouch Pro/One or equal.

B. Minimum thermostat features shall include, but not limited to, the following:
   1. The thermostat shall have a touch screen and shall display both room temperature and cooling and heating setpoints simultaneously and shall indicate when cooling or heating and what stage is energized on the main screen.
   2. Programming may be accomplished at the thermostat, or via free software. The program shall have an override mode to provide comfort on demand while in an unoccupied period. The unoccupied override shall be adjustable by pushing an override button and selecting thirty minute increments, up to four hours.
   3. The setback override shall be activated by a single button and deactivated on demand.
   4. Setpoints shall be adjustable from 35°F to 99°F, with a minimum 5°F adjustable dead band available.
   5. Dual setpoints shall be provided with the ability to individually set heating and cooling temperatures with adjustable heating and cooling setpoint limits. Initial occupied mode cooling setpoint of 75°F and heating setpoint of 70°F. Initial unoccupied mode cooling setpoint of 85°F and heating setpoint of 55°F

C. The fan shall be programmable to operate continuously during occupied periods and in auto mode during unoccupied periods.

D. Controls shall be capable of alternating compressor starting sequence with a built in lead-lag operating logic.
   1. Equipment protection options shall be provided to prevent compressor short-cycling, and to limit the number of cycles per hour. These options shall be overridden for use with zoning systems.

E. Pre-Occupancy purge cycle that energizes the fan before the programmed occupancy time, adjustable up to three (3) hours in 15-minute increments.
   1. Configurable terminals shall be provided for remote indoor, remote outdoor or remote supply air temperature sensing.

F. Multiple security levels to limit access to programming and configuration and will allow for a custom passcode. The various security levels will allow controlled access to programming, unoccupied override, and thermostat mode.

G. All programming information, except time of day, shall reside in nonvolatile memory. During a power failure, the thermostat shall maintain its program indefinitely without the use of batteries. Wi-Fi capable and controlled through local wireless internet routers. The thermostat shall be capable of receiving an automated demand response signal from the local electrical utility, and automatically reset the cooling and heating setpoints during the demand event. When the demand event is terminated by the local electrical power utility, the thermostat will reset to normal occupied and unoccupied setpoints.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Examine site to verify if site is ready to receive work. Provide a layout drawing of fan locations to electrical installer.

C. Install minimum MERV-8 efficiency air filters in unit during installation phase. Do not operate the unit without filters in place.

D. Install unit supported by vibration isolation springs.

E. Install 3" flexible duct connection at inlets and outlets of units.

F. Install condensate drain piping and traps in accordance with manufacturer's instructions and as shown on the Drawings.

G. Provide and install condensate pump as required and as shown on the Drawings. Coordinate with plumbing design and electrical design as necessary.

H. Control installers shall install all control conduit and wiring associated with control functions required as shown on the drawings.

I. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

J. Install a new set of filters prior to final air balance. If these filters become dirty due to ongoing construction or fans were operational for more than thirty days following the final air balance, provide and install an additional new set of filters prior to Certificate of Occupancy. The Owner’s Representative shall determine if filters are acceptable.

3.2 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, start-up the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four hours of travel from the job site.

END OF SECTION 238219

SECTION 238230

HEATING UNITS

PART 1 - GENERAL

1.1 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Unit heaters.
   2. Cabinet heaters.
   3. Wall mounted electric cabinet heaters.
   4. Small air-to-air heat recovery ventilators

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230716: Equipment Insulation

D. Section 230900: Building Automation System (BAS) Controls

E. Section 232113: Hydronic Piping, Valves and Specialties

F. Section 232123: Hydronic Pumps

G. Section 233113: Air Distribution

H. Section 233412: Air Handling Equipment

I. Section 235200: Heat Generation

J. Division 26: Electrical

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide components and pumps conforming to the requirements of the latest addition of the following:
   1. American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Code
      a. Section VIII D1 -Rules for Construction of Pressure Vessels including Addendums
      b. Section VIII D2 - Rules for Construction of Pressure Vessels including Addendums
      c. Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators including Addendums
      d. B31.1 - Power Piping
   2. National Electrical Manufacturers Association (NEMA): Provide electrical components that comply with NEMA Standards.
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for units showing dimensions, weights (shipping, installed, and operating), capacities, ratings, performance with operating point clearly indicated, motor electrical characteristics, finishes of materials, and installation instructions.

B. Shop Drawings: Submit manufacturer's shop drawings indicating dimensions, weight (shipping, operating), required clearances, methods of assembly of components, and location and size of each field connection.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, tube replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver units to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect units against dirt, water, chemical, and mechanical damage. Do not install damaged units - remove from project site.

C. Rigging: Comply with the manufacturer's rigging and installation instructions.

1.6 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 - PRODUCTS

2.1 UNIT HEATERS (ELECTRIC)

A. General:
1. The contractor shall furnish and install electric unit heaters of type, size, and voltage specified in schedule on plans. Heaters shall be installed and wired in accordance with the manufacturer's recommendations and applicable national and local codes.

B. Casing:
1. Casings shall be fabricated of die formed heavy gauge steel and finished in high gloss, baked enamel. Supply air shall be drawn and discharged through an outward drawn venture. Adjustable discharge louvers shall be provided to control the direction of airflow. A large hinged access door shall extend the width of the heater and be locked in position by quarter turn fasteners. Heater and supply wiring diagram shall be permanently attached to the inside of the access door.

C. Elements:
1. Elements shall be high mass, all steel, tubular finned type, copper brazed.

D. Motors:
1. Motor shall be totally enclosed. All units 3.3 through 20 kW will utilize sealed bearings to ensure permanent lubrication. 25 through 50 kW units are provided with a two speed, permanent capacitor type, lubricated for 5 years of continuous or ten years of intermittent use.

E. Fan Blades:
1. Fan blades shall be of the axial flow type designed for quiet, efficient operation. Fan speed shall not exceed 1,600 rpm.

F. Wiring:
1. Heaters shall be designed for a single circuit, with elements, motor, and control circuits subdivided with factory fuses to conform to the National Electric Code and Underwriter's Laboratory, Inc. Standard 1025. All three-phase heaters shall have balanced phases.

G. Thermal Overload Protection:
1. All heaters shall be equipped with automatic reset thermal overloads that shut down the element and motor if safe operating temperatures are exceeded.

H. Controls:
1. Contactors and control circuit transformers, where required, shall be factory installed and wired. Only direct line supply and thermostat connections are field wired. Two stage operation is provided on all units 25 Kw and larger. Built-in fan override shall be provided to purge unit casing of excess heat after unit shutdown. The units shall be listed under the Re-examination Service of Underwriters' Laboratories, Inc. Units shall be warranted to be free from defective material and workmanship for a period of one year with the exception of the heating elements that shall be warranted for five years.

I. Control Options:
1. Power disconnects supplied for field installation where applicable shall disconnect all ungrounded connectors in the "Off" position.
2. Thermostat shall be (unit mounted) (wall mounted) and shall be heavy-duty hydraulic actuating type. Thermostat range shall be 45°F to 90°F. Unit mounted thermostat shall be rendered tamperproof by removing the temperature adjustment knob.
3. Independent fan operation of summer air circulation shall be provided from a line or low voltage (unit mounted) (wall mounted) fan switch.
4. Combination low voltage wall thermostat and fan switch shall be provided to give remote control of thermostat and fan.
5. Stratification thermostat with a range of 70°F to 130°F shall be available for units mounted in the vertical discharge position to provide an energy saver cycle recovering warm stratified air.

J. Manufacturers: Berko, Trane, Q-Mark, Reliance or equal.

2.2 CABINET HEATERS

A. General:

B. Basic Unit:
1. Includes chassis, coil, fan board, fan wheel(s), housing(s), motor, and insulation. Chassis is galvanized steel wraparound structural frame with all edges flanged. Insulation is faced, heavy density glass fiber.
2. Vertical cabinet models; 16-gauge steel front panels and 18-gauge steel end and top panels have channel formed edges around entire panel perimeters. Front panel insulated over entire coil section. Integral, stamped outlet grilles have 15° deflection from vertical. Stamped lattice discharge grilles on inverted airflow models. Access door on coil connection side of unit. Front panel removable without tools.
3. Vertical recessed models; 16-gauge steel, four side overlap front panels, with M-shaped stiffener running entire panel length as standard. Integral, stamped, inlet and outlet grilles have 15° downward deflection. Front panel insulated over entire coil section. Front camlocked access doors on right hand side of unit. Front panel removed with two screws. Panel depths from 5/8" to 5-1/8" in 800-1,800 cfm units.
4. Horizontal cabinet models; 18-gauge steel panels. Bottom and end panels have channel formed edges around entire panel perimeter. Integral, stamped outlet grilles have 15° downward deflection. Stamped lattice inlet grilles. Bottom panel hinged at front and camlocked at back.

5. Horizontal recessed models; 18-gauge steel, removable, four side overlap bottom panel adjustable 3/8" with full length, piano type hinge at back and camlocks at front.
6. Cabinet finish: All cabinet parts cleaned, bonderized, phosphatized, and painted with light gray baked on enamel finish as standard. Optional baked on enamel in eight decorator colors (chestnut brown, forest green, platinum gray, redwood, pale gold, flat black, bronze tone, or shell white) are available. Standard and optional finish meet Corps of Engineers specifications CE301.37 (salt spray test).

C. Coils:
1. Water coils; 5/8" OD seamless copper tubes mechanically bonded to configured aluminum fins with continuous fin collars and sleeved coil end supports. Maximum working pressure 300 psig, factory burst test 450 psig (air), and leak test 300 psig (air under water). Maximum entering water temperature 275° F. Supply and return connections on same side of units on all models and sizes.
2. Steam Coils; 1 inch OD seamless copper tubes mechanically bonded to configured aluminum fins with continuous fin collars and sleeved coil end supports. Maximum working pressure 75 psig for Type B steam coil, and 100 psig on Type F steam distributing coil. Factory leak test 250 psig (air under water). Maximum entering steam temperature 325° F for standard coil (Type B) and 400° F for steam distributing coil (Type F). Steam distributing coils have cast iron headers. Supply and return connections on same side of units on all models and sizes.
3. Electric Heating Coils: Hydronic type finned tube construction with resistance elements inserted in tubes on 200-600 cfm units; spiral sheath type on 800-1,800 cfm units. Units factory wired with unit mounted heat switch, magnetic contactors, high temperature cutout safety control, and fan override thermostat.

D. Fans:
1. Fan wheels centrifugal, forward curved, double width of non-corrosive, molded, fiberglass reinforced thermo-plastic material on all units except electric heat and inverted airflow models which use aluminum. Fan housings of formed sheet metal on 200-600 cfm units; 800-1,800 cfm units have end caps made of non-corrosive molded, fiberglass reinforced thermo-plastic material, and fan scrolls of galvanized steel.

E. Motors:
1. All motors have integral thermal overload protection and start at 87% of rated voltage. Motors operate satisfactorily at 89% of rated voltage on all speed settings and at 10% over voltage without undue magnetic noise. Temperature rise by winding resistance method does not exceed 60□ C (shaded pole motors) and 50□ C (PSC motors) on high speed. All motors factory run tested assembled in unit prior to shipping. Motor cords quickly detachable at junction box by locking prong connector.

F. Filters:
1. Removable from vertical cabinet models without removing front panel; from horizontal units by pivoting hinged bottom panel. 1" woven glass filters standard.
2. Options include 1/2" permanent, cleanable aluminum mesh; 1/2" renewable media in permanent aluminum frame; and 1" replaceable media of woven glass fiber with 1" permanent aluminum frame.

G. Electrical Performance: All cataloged models wired in accordance with National Electric Code. Option, Underwriters Laboratories, Inc. listed. Junction box for motor cord provided unless otherwise specified.

H. Manufacturers: Daikin, Rittling, Trane, Modine, Vulcan or equal.

2.3 WALL MOUNTED ELECTRIC CABINET HEATERS

A. General: Provide heavy duty electric wall heater for surface mount. QDOT, Markel, or equal.

B. Heater element: Non-glowing design of 80/20 nickel-chromium resistance wire enclosed in steel sheath to which plate fins are copper brazed.

C. Fan and motor: Aluminum bladed fan with totally enclosed motor.

D. Fan Delay Switch: Fan control shall be of bi-metallic, snap-action type and shall activate fan after heating element reaches operating temperature. Fan shall continue to operate after the thermostat is satisfied until heating element is cool.

E. Thermostat: Tamper proof thermostat shall be of the bimetallic, snap-action type with enclosed contacts. It shall be completely concealed behind the front cover to become tamper proof.

F. Thermal Cutout: Provide cutout built into the system to shut off heater in the event of overheating.

G. Disconnect: A double-pole single throw disconnect switch shall be mounted on the back box for positive disconnect of the power supply. It will be completely concealed behind the front grid panel.

H. Front Panel: Bar grille type constructed of 16-gauge cold-rolled steel, welded into a uniform grille and finished in bronze brown baked enamel to direct the warmed air toward the floor.

I. Back Box: 20-gauge galvanized steel with knockouts for power leads. Box to be used with the mounting frame for surface mounting application.

2.4 CEILING MOUNTED ELECTRIC CABINET HEATERS

A. General: Provide heavy duty electric heater for flush surface ceiling mount.

B. Heater element: Non-glowing design of 80/20 nickel-chromium resistance wire enclosed in steel sheath to which plate fins are copper brazed.

C. Fan and motor: Aluminum bladed fan with totally enclosed motor.

D. Fan Delay Switch: Fan control shall be of bi-metallic, snap-action type and shall activate fan after heating element reaches operating temperature. Fan shall continue to operate after the thermostat is satisfied until heating element is cool.

E. Thermostat: Tamper proof thermostat shall be of the bimetallic, snap-action type with enclosed contacts. It shall be completely concealed behind the front cover to become tamper proof.

F. Thermal Cutout: Provide cutout built into the system to shut off heater in the event of overheating.

G. Disconnect: A double-pole single throw disconnect switch shall be mounted on the back box for positive disconnect of the power supply. It will be completely concealed behind the front grid panel.

H. Ceiling Panel: Similar in appearance to ceiling mounted louver faced grille. Grille assembly shall be constructed of a one-piece heavy gauge steel with ¼" square slots for return air and concentric rings for uniform supply air discharge.

I. Back Box: 20-gauge galvanized steel with knockouts for power leads. Box to be used with the mounting frame for surface mounting application.

J. Manufacturers: QDOT, Markel #3480 Series or equal.

2.5 SMALL AIR-TO-AIR HEAT RECOVERY VENTILATORS

A. General:
1. The energy recovery ventilator (ERV) shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, control circuit board and blowers with motors, filters, and insulated foam air guides. Each unit will have an automatic by-pass damper

system for economic operation under certain conditions. The unit shall have factory installed control board with functions for local, remote, and optional control modes.

B. Construction:
1. The energy recovery component shall be of fixed-plate cross-flow construction, with no moving parts.
2. No condensate drain pans or drains shall be allowed and unit shall be capable of operating in both winter and summer conditions without generating condensate.
3. The unit case shall be constructed of G90 galvanized, 20-gauge steel, with lapped corners and zinc plated screw fasteners.
4. Access doors shall provide easy access to blowers, ERV cores, and filters. Doors shall have an airtight compression seal using closed cell foam gaskets. Pressure taps, with captive plugs, shall be provided allowing cross-core pressure measurement allowing for accurate airflow measurement.
5. Case walls and doors shall be insulated with 1 inch, 4 pound density, foil/scrim faced, high-density fiberglass board insulation, providing a cleanable surface and eliminating the possibility of exposing the fresh air to glass fibers, and with minimum R-value of 4.3 (hr·ft2·°F/BTU).
6. The ERV cores shall be protected by a MERV-8 rated, 2” nominal, pleated, disposable filter in both airstreams.
7. Unit shall have single-point power connection and a single-point 24 VAC contactor control connection.

C. Blowers:
1. Blower motors shall be Premium Efficiency, EISA compliant for energy efficiency. The blower motors shall be totally enclosed (TEFC) and be shall be supplied with factory installed motor starters (HE6X and HE8X 208-230/460V models are open drip-proof). Direct drive models (EV450 and HE1X models) shall be EISA-compliant for energy efficiency with open drip proof design and integral thermal protection.
2. Blowers shall be quiet running, forward curve type and be either direct drive (EV450 and HE1X only) or belt drive. HE6X and HE8X units use backward incline, belt drive blower packages. Belt drive motors shall be provided with adjustable pulleys and motor mounts allowing for blower speed adjustment, proper motor shaft orientation and proper belt tensioning.

D. Electrical:
1. The unit electrical box shall include a factory installed, non-fused disconnect switch and a 24 VAC, Class II transformer/relay package.
2. The ERV shall be provided “inverter-ready” allowing for applications of inverters supplied and installed by others.

E. Required Options:
1. Provide unit and duct connection orientation per project schedule.
2. Units are available single or three phase at a full range of operating voltages. See project schedule.
3. Provide motor horsepower as specified in project schedule.
4. Provide factory installed disconnect fuses.
5. Provide factory installed filter monitors for each airstream.
6. Provide MERV-13 filters for final installation after construction phase.

F. Electric Supply Air Coil:
1. General: Provide an electric on the downstream fresh air discharge from the ERV. Provide a primary automatic reset thermal cutout, a manual reset secondary thermal cutout, line fusing, mercury contactors per element, differential pressure airflow switch for proof of flow, and line terminal block. Coil shall be capable of operating under continuous duty at 120°F discharge temperature. Unit shall include an integral door interlock type disconnect switch which will

not allow the access door to be opened while power is on. Coordinate final voltages with Div. 26.

2. Manufacturer: Indeeco or equal.
3. Approvals - Heaters and panelboards (if required) shall meet the requirements of the National Electrical Code and shall be listed by Underwriters Laboratories for zero spacing between the duct and combustible surfaces and for use with heat pumps and air conditioning equipment.
4. Heating elements shall be open coil, 80% nickel, 20% chromium, Grade A resistance wire. Type C alloys containing iron or other alloys are not acceptable. Coils shall be machine crimped into stainless steel terminals extending at least 1" into the airstream and all terminal hardware shall be stainless steel. Coils shall be supported by ceramic bushings staked into supporting brackets.
5. Heater frames and terminal boxes shall be corrosion resistant steel. Unless otherwise indicated, the terminal box shall be NEMA 1 construction and shall be provided with a hinged, latching cover and multiple concentric knockouts for field wiring.
6. All heaters shall be furnished with a disc type, automatic reset thermal cutout for primary over temperature protection. All heaters shall also be furnished with disc type, load-carrying manual reset thermal cutouts, factory wired in series with heater stages for secondary protection. Heat limiters or other fusible over temperature devices are not acceptable.
7. Heaters shall be rated for the voltage, phase and for use with SCR controller for proportional heating control. All three-phase heaters shall have equal, balanced, three-phase stages. All internal wiring shall be stranded copper with 105°C insulation and shall be terminated in crimped connectors or box lugs.
8. Terminal blocks shall be provided for all field wiring and shall be sized for installation of 75°C copper wire rated in accordance with NEC requirements.
9. Controls: Heaters shall be furnished with the Control Option specified in the schedule and described below or with the specific components listed in the schedule.
10. Required Options:
    a. SCR control.
    b. Fan relay and airflow switch

G. Manufacturers: Renewaire, Venmar, Lossnay, Daikin or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All equipment, unless otherwise shown or noted on the Drawings, is to be installed in accordance with industry standards and manufacturer's recommended installation instructions.

B. Provide vibration isolation, inertia bases, seismic snubber, flexible pipe connections, etc, as specified in related specification sections.

C. Mechanical contractor to assist testing and balancing contractor in verifying correct pump rotation and system operation.

D. Flush and clean equipment, in accordance with manufacturer's start-up instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls.

E. Contractor to coordinate all electrical requirements with electrical contractor.

3.2 INSTALLATION SPECIFICS FOR AIR-TO-AIR HEAT RECOVERY VENTILATOR

A. Ductwork: The installer shall supply, install, test and commission all interconnecting ductwork for the energy recovery unit.

B. Ductwork sizing, layout, fittings, etc shall be in strict accordance with the design requirements.

C. The outside air and exhaust air ducts connected to exterior louvers must be covered with heat insulating material in order to prevent condensation from forming and must be tilted at a gradient of 1:30 toward the outdoor louver.

3.3 MANUFACTURER'S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify pump systems mounting, verify piping installation, verify control wiring, verify power wiring, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four-hours travel from the job site.

END OF SECTION 238230

SECTION 260500

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Provide equipment and materials which conform to the standards effective as of the date of the Contract Documents as promulgated by the following bodies:
   1. Underwriters' Laboratories (UL).
   2. National Electrical Manufacturers' Association (NEMA).
   3. Electrical Testing Laboratories (ETL).
   4. American National Standards Institute (ANSI).
   5. Insulated Cable Engineers Association (ICEA).
   6. State Fire Marshal (SFM).
   7. National Electrical Code (NEC).
   8. Washington State Energy Code (WSEC)

1.2 SUBMITTALS

A. Submit electronic copies of manufacturer's submittal sheets or shop drawings for major items of electrical equipment and for any items specifically requested by the Electrical Engineer. When possible, make all electrical submittals at the same time.

1.3 INSTALLATION DRAWINGS

A. Prepare dimensionally accurate floor plans of each electrical and signal room and/or closet, fire control room and the like, drawn to 1/4" scale minimum. Submit electronic copies for review with two prints for Architect's record. Indicate all equipment within the rooms to scale based on shop drawing data, include structural support for suspended equipment and description of seismic bracing and fastening. Indicate system and equipment grounding details as applicable. Review elevator machine room shop drawings and coordinate location of electrical gear to maintain clearances. Submit with shop drawings.

B. Where conduit runs, 2" trade size and larger, are run in exposed locations, prepare dimensionally accurate floor plans indicating routing, coordinated with work of other trades and the structure. Submit legible reproducible transparencies with two prints for review.

1.4 PROJECT RECORD DOCUMENTS

A. Maintain Record Documents which clearly indicate variances from the specified systems and which accurately locate all underground electrical conduits and structures.

1.5 EXAMINATION OF DOCUMENTS

A. Before submitting a bid, visit the Project Site and become familiar with conditions which may be pertinent to, or affect the cost of, the electrical installation.

B. Become acquainted with the Work of other installers whose activities will adjoin or be affected by the electrical Work. Consult with these other installers and study all pertinent Drawings in order to coordinate the Work and to avoid conflicts, omissions and delays.

1.6 PERMITS AND FEES

A. Obtain and pay for all necessary electrical permits and fees.

1.7 SUBSTITUTIONS

A. Substitution request shall be submitted before Bid.

1.8 DRAWINGS

A. For purposes of clarity and legibility, the electrical Drawings are essentially diagrammatic. although the size and location of electrical equipment is drawn to scale wherever possible, make use of all data in all of the Contract Documents, and verify this at the Project Site. Determine the exact location of conduits, outlets and equipment by the study of details, shop drawings and/or the Architect's directions.

B. The electrical Drawings show the required size and points of termination of the conduits and the quantity and size of the conductors within. However, the Drawings do not show all of the necessary conduit bends. Install conduits in such a manner as to conform to structure, avoid obstruction, preserve headroom and keep passageways and openings clear.

C. Locate outlets symmetrically with architectural elements, notwithstanding the fact that the locations shown of the electrical drawings may be distorted for clarity of representation.

D. The architectural Drawings take precedence over the electrical Drawings. Study the reflected ceiling plans and interior elevations to determine the exact location of lighitng fixtures, wall-mounted devices and fixtures, etc. The Architect has taken a very active role in the placement of these items. Should there be a conflict between locations shown on the architectural and electrical drawings, contact the Engineer for clarification prior to rough-in.

E. Before submitting a bid, examine all pertinent Contract Documents for electrical requirements which are not necessarily indicated on the electrical Drawings and include in the bid a sum which is sufficient to cover the costs of these other requirements.

F. Should it be perceived that the Contract Documents do not sufficiently define the required electrical work, contact the Architect for clarification or further description. Failure to do this will be construed as evidence of an understanding of the required electrical systems and their installation.

1.9 REQUESTS FOR INFORMATION (RFIs)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 1).
   1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
   2. RFIs shall address single questions and related issues only.
   3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to Owner’s Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
   1. Project name.
      a. Project number.
      b. Date.
      c. Name of Contractor.
      d. Name of Architect.
      e. RFI number, numbered sequentially and unique.
      f. RFI subject.
      g. Specification Section number and title and related paragraphs, as appropriate.
      h. Drawing number and detail references, as appropriate.

i. Field dimensions and conditions, as appropriate.
j. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
k. Contractor's signature.
l. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
1) Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.
1. The following Contractor-generated RFIs will be returned without action:
a. Incomplete RFIs or inaccurately prepared RFIs.
b. RFIs submitted without indication of review and approval for submission by General Contractor.
c. RFIs addressing multiple unrelated issues.
d. Requests for approval of submittals.
e. Requests for approval of substitutions.
f. Requests for approval of Contractor's means and methods.
g. Requests for information already indicated in the Contract Documents.
h. Requests for adjustments in the Contract Time or the Contract Sum.
i. Requests for interpretation of Engineer's actions on submittals.
2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

1.10 VERIFICATION OF AVAILABLE SPACE

A. Throughout the course of construction, verify that sufficient space will be available for the equipment to be installed.

1.11 IDENTIFICATION MARKINGS

A. Switchboards, distribution and branch panelboards, terminal cabinets and other miscellaneous electrical equipment shall be identified with laminated black and white engraved plastic nameplates which properly identify each item. Nameplates shall be attached with steel rivets or bolts and nuts.

1.12 EXISTING FACILITIES

A. Examine the drawings and specifications of the completed work and inspect the site to establish the scope of demolition work and new work to be provided under this sections and clarification of the phasing of the work.

B. Based on project phasing and scheduling, demolition work will be taking place in and around existing areas that are to remain in service. Where the work under this section affects or interferes with the operation of any existing areas to remain in service, or portions of the work already in operation, provide all necessary work and material including premium pay, required to avoid shutdown of these areas during normal operations. Obtain Owner's approval for shutdown, in writing, 48 hours prior to shutdown.

C. Existing electrical and signal facilities outside of the demolition area to remain in place and in service during demolition.

D. Unless specifically noted or otherwise indicated or directed, remove all existing electrical equipment in the areas to be demolished. Deliver all equipment removed, including lighting fixtures, to the Owner's representative.

1.13 REMODELING

A. Where remodeling of existing areas is indicated, provide all work indicated and required for a complete and operating facility. Where work is adjacent to existing fixtures or devices, provide matching products to present uniform appearance. Salvage demolished material and equipment and deliver to Owner as directed. Dispose of salvaged materials and equipment where so directed in writing by Owner. Patch all openings in existing walls or floors caused by removal of materials and/or equipment under this work.

1.14 DEMOLITION

A. Where areas of existing facilities are indicated to be demolished or remodeled, visit site to determine scope of work. Relocate electric and signal system equipment, and reroute or replace conduit and wiring as required to conform with new use of the area and maintain operation of adjacent areas.

1.15 WATERPROOFING

A. Wherever electrical Work pierces waterproofing or waterproofing membranes, install it in an approved watertight manner.

1.16 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Protect electrical equipment and materials during transit, storage and handling to prevent damage, soiling and deterioration.

B. Provide new electrical materials and deliver them to the Project Site in unbroken packages.

1.17 CUTTING AND PATCHING

A. Provide core drilling, cutting and patching of existing construction and surfaces for the installation of electrical systems. Concrete, asphalt or plaster surfaces which have been damaged by such drilling or cutting shall be patched and repaired to match the surrounding surface.

1.18 ADJUST AND CLEAN

A. Keep the Project Site free from accumulations of electrical rubbish and debris. Remove such accumulations from the Project Site.

B. Thoroughly clean electrical equipment and materials of plaster, cement and other foreign materials and leave smooth, clean and dry.

1.19 FIELD QUALITY CONTROL

A. At project Completion or upon request of the Architect anytime, make necessary tests under the observation of the Architect which will ensure that electrical equipment, materials and installation methods are as specified.

B. At Project Completion, test electrical loads and controls under full operating conditions and immediately replace, at no cost to the Owner, defective electrical equipment, devices and workmanship. Make standard electrical equipment, materials and performance tests and also tests as may be required by the Architect, such as electrical insulation and ground resistance, or temperature rise.

C. Closing-in of Work: Do not allow Electrical Work to be covered or enclosed until it has been observed by the Architect's Representative. Should unobserved Electrical Work be covered or enclosed, uncover it for observation and then make repairs as necessary to restore the Electrical Work and the Work of other affected installers to its original and proper condition, at no cost to the Owner.

PART 2 - PRODUCTS

2.1 NOT USED.

PART 3 - EXECUTION

3.1 NOT USED.

END OF SECTION 2605000

SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Copper building wire rated 600 V or less.
2. Aluminum building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Armored cable, Type AC, rated 600 V or less.
5. Photovoltaic cable, Type PV, rated 2000 V or less.
6. Mineral-insulated cable, Type MI, rated 600 V or less.
7. Tray cable, Type TC, rated 600 V or less.
8. Fire-alarm wire and cable.
9. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:
1. Section 271313 "Communications Copper Backbone Cabling" for twisted pair cabling used for data circuits.
2. Section 271513 "Communications Copper Horizontal Cabling" for twisted pair cabling used for data circuits.

1.2 DEFINITIONS

A. PV: Photovoltaic.

B. RoHS: Restriction of Hazardous Substances.

C. VFC: Variable-frequency controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cerro Wire LLC.
   2. General Cable Technologies Corporation.
   3. Southwire Company.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B496 for stranded conductors.

E. Conductor Insulation:
   1. Type NM: Comply with UL 83 and UL 719.
   2. Type THHN and Type THWN: Comply with UL 83.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cerro Wire LLC.
   2. General Cable Technologies Corporation.
   3. Southwire Company.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. See the Evaluations for discussion of UL's "Wire and Cable Marking and Application Guide."
   4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

E. Conductor Insulation:
   1. Type NM: Comply with UL 83 and UL 719.
   2. Type THHN and Type THWN: Comply with UL 83.

2.3 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems; a part of Atkore International.
   2. Alpha Wire Company.
   3. General Cable Technologies Corporation.
   4. Southwire Company.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. Comply with UL 1569.

3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:
1. multicircuit with color-coded conductors.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors Aluminum, complying with ASTM B800 and ASTM B801.

F. Ground Conductor: Insulated.

G. Conductor Insulation:
1. Type THHN/THWN-2: Comply with UL 83.

H. Armor: Steel, interlocked.

I. Jacket: PVC applied over armor.

2.4 ARMORED CABLE, TYPE AC

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems; a part of Atkore International.
2. Alpha Wire Company.
3. General Cable Technologies Corporation.
4. Southwire Company.

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Comply with UL 4.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:
1. multicircuit with color-coded conductors.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors, Aluminum, complying with ASTM B800 and ASTM B801.

F. Ground Conductor: Insulated.

G. Conductor Insulation: Type THHN/THWN-2. Comply with UL 83.

H. Armor: Steel, interlocked.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M Electrical Products.
   2. AFC Cable Systems; a part of Atkore International.
   3. Hubbell Power Systems, Inc.
   4. O-Z/Gedney; a brand of Emerson Industrial Automation.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
   1. Material: Copper, Aluminum.
   2. Type: Two hole with standard barrels.
   3. Termination: Compression.

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. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

D. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-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 or Metal-clad cable, Type MC.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

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 (150 mm) of slack.

D. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

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: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform 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 for compliance with requirements.
   2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance conductors
   3. Perform each of the following visual and electrical tests:
      a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
      b. Test bolted connections for high resistance using one of the following:
         1) A low-resistance ohmmeter.
         2) Calibrated torque wrench.
         3) Thermographic survey.
      c. Inspect compression-applied connectors for correct cable match and indentation.
      d. Inspect for correct identification.
      e. Inspect cable jacket and condition.
      f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
      g. Continuity test on each conductor and cable.
      h. Uniform resistance of parallel conductors.
   4. Initial Infrared Scanning: After Substantial Completion, but before 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. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      b. 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.
   5. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports 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.

END OF SECTION 260519

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Informational Submittals: 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.
   5. Grounding for sensitive electronic equipment.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Instructions for periodic testing and inspection of grounding features at test wells and grounding connections for separately derived systems based on NETA MTS.
      a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      b. Include recommended testing intervals.

1.5 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 UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

D. 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. Minimum length shall be 18 inches or as shown on drawings. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

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. Provide exothermic where shown on drawings and where extending main service ground

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch in diameter by 10 feet.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
2. Backfill Material: Electrode manufacturer's recommended material.

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. 2/0 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 and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus on insulated spacers 2 inches minimum from wall, 18 inches above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

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 OVERHEAD LINES

A. Comply with IEEE C2 grounding requirements.

B. Install two parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.

C. Drive ground rods until tops are 12 inches below finished grade in undisturbed earth.

D. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.

E. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.

F. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.

G. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   4. Single-phase motor and appliance branch circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. 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.
   8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. 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.

F. 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.

G. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
   1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-18-inch grounding bus.
   3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

H. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "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.
   2. 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. Install bonding 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.

J. Ufer Ground (Concrete-Encased Grounding Electrode): 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.

3.6 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
   1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.7 FIELD QUALITY CONTROL

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, and at ground test wells. 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 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

B. Related Sections include the following:
   1. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.3 PERFORMANCE REQUIREMENTS

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Nonmetallic slotted channel systems. Include Product Data for components.
   4. Equipment supports.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

B. Comply with NFPA 70.

1.7 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. Fabco Plastics Wholesale Limited.
d. Seasafe, Inc.
2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored 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 malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Hilti Inc.
2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated [stainless] steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type 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.

2.2 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 Division 05 Section "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 except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other 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] single-bolt conduit clamps [single-bolt conduit clamps using spring friction action for retention in support channel].

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) 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, EMT may be supported by openings through structure members, as permitted in 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 (90 kg).

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 (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS 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 meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "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 (100 mm) 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 **2500 psi (17.25 MPa)**, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete ."

C. Anchor equipment to concrete base.
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 (0.05 mm).

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 260533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:
1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. NBR: RNC: Rigid nonmetallic conduit

H. ARC: Aluminum rigid conduit.

I. GRC: Galvanized rigid steel conduit.

J. IMC: Intermediate metal conduit.

1.3 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.4 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.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.
5. Electri-Flex Company.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. O-Z/Gedney; a brand of EGS Electrical Group.
9. Wheatland Tube Company; a division of John Maneely 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. IMC: Comply with ANSI C80.6 and UL 1242.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. FMC: Comply with UL 1; zinc-coated steel or aluminum.

H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

I. 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.
b. Type: Set screw.
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.

J. Joint Compound for IMC, GRC: 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 PVC-COATED STEEL CONDUIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
1. Kor Kap
2. Perma-Cote
3. Plasti Bond
4. Thomas & Betts

B. Description: PVC-coated rigid steel conduit.
1. ETL Verified and must bear the ETL PVC-001 label.
2. Hot dip galvanized inside and out.
3. Comply with NEMA RN 1.
4. PVC Coating Thickness: 0.040 inch (1 mm), minimum.
5. Conduit must have a urethane coating on the interior of all conduit and fittings

a. Urethane coating thickness: .002 inch (.05 mm), minimum.

C. Fittings for Conduit; listed for type and size raceway with which used, and for application and environment in which installed.
1. Condulets 1/2” through 2” diameter shall have tongue-in-groove gasket.
2. Condulets be supplied with plastic encapsulated stainless steel cover screws.

2.3 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.
6. Condux International, Inc.
7. Electri-Flex Company.
8. Lamson & Sessions; Carlon Electrical Products.
9. ElecSYS, Inc..

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. RTRC: Comply with UL 1684A and NEMA TC 14.

I. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

J. Fittings for LFNC: Comply with UL 514B.

K. 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).

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
1. Cooper B-Line, Inc.
2. Hoffman; a Pentair company.
3. Square D; a brand of Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R, Type 4, or Type 12 as shown on drawings, 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.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

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. Hoffman; a Pentair company.
2. Lamson & Sessions; Carlon Electrical Products.

B. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

E. 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).

2.6 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. Manufacturer's standard enamel finish in color selected by Architect.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems Division.
b. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems Division.
b. Wiremold / Legrand.

2.7 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Technologies Company; Cooper Crouse-Hinds.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman; a Pentair company.
5. Hubbell Incorporated; Killark Division.
6. O-Z/Gedney; a brand of EGS Electrical Group.
7. RACO; a Hubbell Company.
8. Thomas & Betts Corporation.
9. 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.
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 (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) 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 (32 kg).
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 (100 mm square by 60 mm deep).

N. Gangable boxes are prohibited.

O. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4, or Type 12 as shown on drawings 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: Plastic .
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

P. Cabinets:
1. NEMA 250, Type 1, Type 3R, or Type 12 as shown on drawings, 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.

2.8 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
      a. Armorcast Products Company.
      b. Carson Industries LLC.
      c. CDR Systems Corporation; Hubbell Power Systems.
      d. NewBasis.
      e. Oldcastle Precast, Inc.; Christy Concrete Products.
      f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
   2. Standard: Comply with SCTE 77.
   3. Configuration: Designed for flush burial with open 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 (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.9 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. 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.
   2. 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 or IMC.
   2. Concealed Conduit, Aboveground: GRC, IMC, or EMT.
   3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried or concrete encased where shown.
   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 3R.

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: EMT Exposed and Subject to Severe Physical Damage: GRC or IMC. 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. Electrical rooms.
   e. Warehouse spaces
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 or IMC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel or nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 1/2-inch (16-mm) to devices with 3/4-inch (21-mm) minimum homerun. 1-inch (32-mm) minimum trade size for ENT underground outdoor use.

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 setscrew or 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 (49 deg C).

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 (150 mm) 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 Division 26 Section "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 (300 mm) 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. A. Support conduit within 12 inches (300 mm) of enclosures to which attached.

I. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch (27-mm) 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 maximum10-foot (3-m) intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches (50 mm) Insert dimension of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

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 (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) 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 (53-mm) 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 (90-kg) tensile strength. Leave at least 24 inches (600 mm) 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-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) 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 (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
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 (70 deg C) temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
   d. Attics: 135 deg F (75 deg C) 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 (0.06 mm per meter of length of straight run per deg C) 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 (0.0115 mm per meter of length of straight run per deg C) 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 (1830 mm) 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.

California Building Code (CBC) reference below are more restrictive than ADA and should be selected for all projects in California Engineer must edit to California or other.

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 top 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 Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Division 31 Section "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 (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "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 (75 mm) of concrete for a minimum of 12 inches (300 mm) 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 (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Division 26 Section "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 (12.5-mm) sieve to No. 4 (4.75-mm) 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 (25 mm) above finished grade.

D. Install handholes with bottom below frost line, 18 inches (450 mm) 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 Division 26 Section "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 Division 07 Section "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 260543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
2. Handholes and boxes.
3. Manholes.

1.2 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:
1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes, and other utility structures.
4. Warning tape.
5. Warning planks.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.4 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 manholes and handholes, as required by ASTM C 858.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT 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 [Architect] [Construction Manager] Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

1.8 COORDINATION

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.

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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Allied Tube & Conduit; a part of Atkore International.
b. Anamet Electrical, Inc.
c. Electri-Flex Company.

d. O-Z/Gedney; a brand of Emerson Industrial Automation.
e. Southwire Company.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Allied Tube & Conduit; a part of Atkore International.
b. Anamet Electrical, Inc.
c. Electri-Flex Company.
d. O-Z/Gedney; a brand of Emerson Industrial Automation.
e. Southwire Company.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ARNCO Corp.
2. Cantex, Inc.
3. Condux International, Inc.
4. Electri-Flex Company.
5. Lamson & Sessions; Carlon Electrical Products.

D. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

F. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."

2.3 PRECAST CONCRETE HANDHOLES AND BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.

C. Comply with ASTM C 858 for design and manufacturing processes.

D. 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. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, As indicated for each service.
4. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.

5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
   a. Extension shall provide increased depth of 12 inches (300 mm).
   b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
6. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
   a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
7. 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.
8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 PRECAST MANHOLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carder Concrete Products.
   2. Christy Concrete Products.
   3. Jensen Precast Co.
   4. Oldcastle Precast Group.
   5. Riverton Concrete Products; a division of Cretex Companies, Inc.
   6. Utility Concrete Products, LLC.
   7. Utility Vault Co.

B. Comply with ASTM C 858 and with interlocking mating sections, complete with accessories, hardware, and features.
   1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
      a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
      b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
      c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.

C. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.

D. 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.

2.5 CAST-IN-PLACE MANHOLES

A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

B. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-Place Concrete."

C. Structural Design Loading: As specified in Part 3 "Underground Enclosure Application" Article.

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables Over 600 V: 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 for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40 or DB-120-PVC, in direct-buried duct bank, unless otherwise indicated.

E. Underground Ducts Crossing Paved Paths Walks and Driveways Roadways and Railroads: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.2 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, [H-10] H-20 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: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin , structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

B. Manholes: Precast concrete.
1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turf and Grasses" and "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.4 DUCT INSTALLATION

A. 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.

B. 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 (1220 mm) , both horizontally and vertically, at other locations, unless otherwise indicated.

C. 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.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
   2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
   3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) 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 Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

G. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.
   1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   2. Concreting Sequence: Pour each run of envelope between 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 (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated on drawings.
7. Stub-Ups: Use manufactured PVC coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
   b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
8. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

I. Direct-Buried Duct Banks:
1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) 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 (150 mm) between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
4. Install backfill as specified in Division 31 Section "Earth Moving."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts unless otherwise shown on drawings.
7. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.

9. Install manufactured PVC coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
   b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
10. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried ducts and duct banks, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole 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 (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:
   1. Manhole Roof: Install with rooftop at least 15 inches (380 mm) below finished grade.
   2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
   3. Install handholes with bottom below the frost line, 18 inches below grade.
   4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) 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. Manhole Access: Circular opening in manhole roof; sized to match cover size.
   1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
   2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section "Elastomeric 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.

F. 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.

G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

I. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.6 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 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 aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
   3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.8 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 260544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

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.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:
1. Steel Pipe Sleeves: ASTM A53/A53M, 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 (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D1785, 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 (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products & Systems, Inc.
      b. CALPICO, Inc.
      c. Metraflex Company (The).
      d. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel.
   4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. HOLDRITE.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. 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 (6.4-mm) 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 (50 mm) 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 (25-mm) 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 (25-mm) 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 260548.16

SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:
1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.
1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.
a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
3. Seismic-Restraint Details:
a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Electrical components include:
   1. Control and monitoring panels.
   2. Luminaires.
   3. Motor control centers.
   4. Panelboards.
   5. Photovoltaic system components.
   6. Switchboards.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

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

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: C.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [**I**] [**II**] [**III**].
      a. Component Importance Factor: 1.5.
      b. Component Response Modification Factor: 5.0.
      c. Component Amplification Factor: 2.5.
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second): .
   4. Design Spectral Response Acceleration at 1.0-Second Period:

2.2 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. Unistrut; Part of Atkore International.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Gripple Inc.
2. Kinetics Noise Control, Inc.
3. Vibration & Seismic Technologies, LLC.
4. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

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

2.5 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.6 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hilti, Inc.
2. Kinetics Noise Control, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

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

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

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:
   1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
   2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

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

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

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

END OF SECTION 260548

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.2 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.

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. Comply with NFPA 70E and Section 260574 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), 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. Color-Coding for Phase- Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
3. Color for Neutral: White or gray.
4. Color for Equipment Grounds: Green.
5. Colors for Isolated Grounds: Green with two or more yellow stripes.

C. Raceways and Cables Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:
1. Identify system voltage with black letters on an orange background.

E. 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 (915 MM)."

F. Equipment Identification Labels:
1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Champion America.
c. emedco.
d. Panduit Corp.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.

b. emedco.
c. Marking Services, Inc.
d. Panduit Corp.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. emedco.
c. Marking Services, Inc.
d. Panduit Corp.
2. Minimum Nominal Size:
a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Panduit Corp.

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.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Champion America.
b. Marking Services, Inc.
c. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. emedco.
c. Marking Services, Inc.

C. Tape and Stencil: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background and are 12 inches (300 mm) wide. Stop stripes at legends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. HellermannTyton.
b. Marking Services, Inc.

D. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Carlton Industries, LP.
b. Seton Identification Products.

E. Underground-Line Warning Tape:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. Marking Services, Inc.
c. Seton Identification Products.
2. Tape:
a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Color and Printing:
a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. emedco.
c. Marking Services, Inc.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Brady Corporation.
b. emedco.
c. Marking Services, Inc.

d. Panduit Corp.

C. Write-on Tags:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Carlton Industries, LP.
   b. LEM Products Inc.
   c. Seton Identification Products.
2. Polyester Tags: 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Carlton Industries, LP.
   b. emedco.
   c. Marking Services, Inc.
2. Preprinted aluminum signs,punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Metal-Backed Butyrate Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. emedco.
   c. Marking Services, Inc.
2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 1/4-inch (6.4-mm) grommets in corners for mounting.
4. Nominal Size: 10 by 14 inches (250 by 360 mm).

C. Laminated Acrylic or Melamine Plastic Signs:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. emedco.
   c. Marking Services, Inc.
2. Engraved legend.
3. Thickness:
   a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
   b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
   c. Engraved legend with white letters on a dark gray background.
   d. Self-adhesive.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Marking Services, Inc.
   2. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 7000 psi (48.2 MPa).
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
   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. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

I. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."
   3. "UPS."

L. Vinyl Wraparound Labels:
   1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
   2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:
   1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
   1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

V. Underground Line Warning Tape:
1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

W. Metal Tags:
1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

X. Nonmetallic Preprinted Tags:
1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose UV-stabilized cable ties.

Y. Write-on Tags:
1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose UV-stabilized cable ties.

Z. Baked-Enamel Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

AA. Metal-Backed Butyrate Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

BB. Laminated Acrylic or Melamine Plastic Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

CC. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. 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.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

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 raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive 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 self-adhesive vinyl tape to identify the phase.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

H. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

J. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

K. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

L. Workspace Indication: Apply floor marking tape to finished surfaces. 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.

M. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
1. Apply to exterior of door, cover, or other access.
2. 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 labels.

P. Operating Instruction Signs: Baked-enamel warning signs.

Q. Emergency Operating Instruction Signs: Baked-enamel warning signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

R. Equipment Identification Labels:
1. Indoor Equipment: Baked-enamel signs.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. 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. Switchgear.
   e. Switchboards.
   f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   g. Substations.
   h. Emergency system boxes and enclosures.
   i. Motor-control centers.
   j. Enclosed switches.
   k. Enclosed circuit breakers.
   l. Enclosed controllers.
   m. Variable-speed controllers.
   n. Push-button stations.
   o. Power-transfer equipment.
   p. Contactors.
   q. Remote-controlled switches, dimmer modules, and control devices.
   r. Battery-inverter units.
   s. Battery racks.
   t. Power-generating units.
   u. Monitoring and control equipment.
   v. UPS equipment.

END OF SECTION 260553

SECTION 260572

SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.2 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.

B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

C. One-Line Diagram: A diagram that 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.

D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

G. SCCR: Short-circuit current rating.

H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

I. Single-Line Diagram: See "One-Line Diagram."

1.3 ACTION SUBMITTALS

A. Product Data:
   1. For computer software program to be used for studies.
   2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
      a. Short-circuit study input data, including completed computer program input data sheets.
      b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
         1) Submit study report for action prior to receiving final approval of 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 selection of devices and associated characteristics is satisfactory.
         2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. For Power Systems Analysis Software Developer.
   2. For Power System Analysis Specialist.
   3. For Field Adjusting Agency.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
   2. The following are from the Short-Circuit Study Report:
      a. Final one-line diagram.
      b. Final Short-Circuit Study Report.
      c. Short-circuit study data files.
      d. Power system data.

1.6 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.
   1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
   2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

D. Power Systems Analysis Specialist Qualifications: Professional engineer 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.

E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.

F. Field Adjusting Agency Qualifications:
   1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
   2. A member company of NETA.
   3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. EDSA Micro Corporation.
   2. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.
   1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. 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 of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:
   1. Protective device designations and ampere ratings.
   2. Conductor types, sizes, 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 and ratings.
   6. Derating factors and environmental conditions.
   7. Any revisions to electrical equipment required by the study.

D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.

E. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
   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 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:
   1. One-line diagram of system being studied.
   2. Power sources available.
   3. Manufacturer, model, and interrupting rating of protective devices.
   4. Conductors.
   5. Transformer data.

G. Short-Circuit Study Output Reports:
   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 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the study.
   1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Architect's attention.
   2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
   3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.

B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. 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 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-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
   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. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
11. Derating factors.

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 device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to 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. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
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.

I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION 260572

SECTION 260573

COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
   1. Study results shall be used to determine coordination of series-rated devices.

1.2 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.

B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

C. One-Line Diagram: A diagram that 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.

D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

E. Power System Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.

G. SCCR: Short-circuit current rating.

H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

I. Single-Line Diagram: See "One-Line Diagram."

1.3 ACTION SUBMITTALS

A. Product Data:
   1. For computer software program to be used for studies.
   2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
      a. Coordination-study input data, including completed computer program input data sheets.
      b. 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 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 selection of devices and associated characteristics is satisfactory.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. For Power System Analysis Software Developer.
   2. For Power Systems Analysis Specialist.
   3. For Field Adjusting Agency.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
   1. The following are from the Coordination Study Report:
      a. Final one-line diagram.
      b. Final protective device coordination study.
      c. Coordination study data files.
      d. List of all protective device settings.
      e. Time-current coordination curves.
      f. Power system data.

1.6 QUALITY ASSURANCE

A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications:
   1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
   2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer 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.

F. Field Adjusting Agency Qualifications:
   1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
   2. A member company of NETA.
   3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. EDSA Micro Corporation.
   2. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
   1. Optional Features:
      a. Arcing faults.
      b. Simultaneous faults.
      c. Explicit negative sequence.
      d. Mutual coupling in zero sequence.

2.2 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:
   1. Protective device designations and ampere ratings.
   2. Conductor types, sizes, 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.
   6. Any revisions to electrical equipment required by the study.
   7. Study Input Data: As described in "Power System Data" Article.
      a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Short-Circuit Studies."

D. 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, and 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.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.

2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
    a. Power utility's overcurrent protective device.
    b. Medium-voltage equipment overcurrent relays.
    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f. Cables and conductors damage curves.
    g. Ground-fault protective devices.
    h. Motor-starting characteristics and motor damage points.
    i. Generator short-circuit decrement curve and generator damage point.
    j. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Maintain selectivity for tripping currents caused by overloads.
6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
7. Provide adequate time margins between device characteristics such that selective operation is achieved.
8. 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 of the Work. 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 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the overcurrent protective device study.
    1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
    2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
    3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.

B. Gather and tabulate all required input data to support the coordination study. 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 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-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
17. Data sheets to supplement electrical distribution system one-line 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 root mean square (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. Switchgear, switchboards, motor-control centers, and panelboards 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 downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.3 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. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to 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 instructions and to IEEE 242.

K. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
   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.

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.
   4. Include in the report identification of any protective device applied outside its capacity.

3.4 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of 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-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:
   1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
   2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
   3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 260573

SECTION 26057

ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 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. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.

C. One-Line Diagram: A diagram that 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.

D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.

F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

G. SCCR: Short-circuit current rating.

H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

I. Single-Line Diagram: See "One-Line Diagram."

1.3 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study 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 Power Systems Analysis Specialist.
   3. Submit study report for action prior to receiving final approval of 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 selection of devices and associated characteristics is satisfactory.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. For Power Systems Analysis Software Developer.
   2. For Power System Analysis Specialist.

3. For Field Adjusting Agency.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
1. Provide maintenance procedures in equipment manuals according to requirements in NFPA 70E.
2. 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.

1.6 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software 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. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash 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.

F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.

G. Field Adjusting Agency Qualifications:
1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. EDSA Micro Corporation.
2. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Conductor types, sizes, and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

G. Arc-Flash Study Output Reports:
   1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
      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. Restricted approach boundary.
   6. Limited approach boundary.
   7. Working distance.
   8. Incident energy.
   9. Hazard risk category.
   10. 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 computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.

B. 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. Protection boundaries.
      a. Arc-flash boundary.
      b. Restricted approach boundary.
      c. Limited approach boundary.
   4. Arc flash PPE category.
   5. Required minimum arc rating of PPE in Cal/cm squared.
   6. Available incident energy.
   7. Working distance.
   8. 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: Perform the Short-Circuit and Protective Device Coordination study prior to starting the Arc-Flash Hazard Analysis.
   1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
   2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

C. Calculate maximum and minimum contributions of fault-current size.
   1. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
   2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
   3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.
   4. Calculate arc-flash energy with the utility contribution at a minimum and assume no motor contribution.

D. Calculate the arc-flash protection boundary and incident energy at locations in 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. Calculate the limited, restricted, and prohibited approach boundaries for each location.

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 shall not be considered beyond three to five cycles.
   2. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for 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 conduct of the arc-flash hazard analysis.
   1. Verify completeness of data supplied on one-line diagram on Drawings. Call discrepancies to Architect's attention.
   2. For new equipment, use characteristics from approved submittals under 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.

3.4 LABELING

A. Apply arc-flash label on the front cover of each section of the equipment for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below shall have an arc-flash label applied to it:
   1. Motor-control center.
   2. Low-voltage switchboard.
   3. Applicable panelboard and safety switch under 250 V.
   4. Control panel.

C. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.
   1. Indicate arc-flash energy.
   2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under the direct supervision and control of Power System Analysis Specialist.

3.6 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels.

END OF SECTION 260574

SECTION 260913

ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes equipment and systems used to monitor and control electrical consumption:
   1. Multifunction meters.
   2. Power meters.
   3. Electrical power monitoring system software.
   4. Network configuration software.
   5. System operator interfaces.
   6. Desktop workstations.

B. Related Requirements:
   1. Section 230923.13 "Energy Meters" for electricity meters for HVAC equipment.
   2. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.2 DEFINITIONS

A. Active Power: The average power consumed by a unit. Also known as "real power."

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.

D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.

F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

G. LAN: Local area network.

H. L-G: Line to ground.

I. L-L: Line to line.

J. L-N: Line to neutral.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

L. Modbus TCP/IP: An open protocol for exchange of process data.

M. 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.

N. N-G: Neutral to ground.

O. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

P. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

Q. TCP/IP: Transport control protocol/Internet.

R. UPS: Uninterruptible power supply; used both in singular and plural context.

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 power monitoring and control.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For power monitoring and control equipment.
1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
1) Location of the meters and gateways, and routing of the connecting wiring.
2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
3. 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.
4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
6. Specifications for workstations.
7. UPS sizing calculations for workstation.
8. Surge Suppressors: Data for each device used and where applied.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:
1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.

f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to do the following:
   1) Design and install new points, panels, and other hardware.
   2) Perform preventive maintenance and calibration.
   3) Debug hardware problems.
   4) Repair or replace hardware.
h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
m. Owner training materials.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power monitoring and control units to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Software licenses.
   3. Software service agreement.
   4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
   5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
   6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
   7. Device address list.
   8. Printout of software application and graphic screens.

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. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.8 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
   1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
   1. Electrical meters that monitor, control, and connect to the data transmission network.
   2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
   3. Include PC-based workstation with web access, with its operating system and application software, connected to data transmission network.

B. The electrical power monitoring and control system shall be Internet based.
   1. System software shall be based on server thin-client architecture, designed around open standards of internet technology.
   2. Intent of thin-client architecture is to provide operators complete access to power monitoring and control system via an Internet browser. No special software other than an Internet browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
   3. Internet access shall be password protected.

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. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
   1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
   2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
   1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor.

2. ASHRAE 135 (BACnet) Modbus communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.

D. Backup Power Source:
1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Schneider Electric USA, Inc.

B. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.
1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Indoor installation in non-air-conditioned spaces that have environmental controls to maintain ambient conditions of minus 4 deg to 158 deg F (minus 20 to plus 70 deg C) dry bulb and 5 to 95 percent relative humidity, noncondensing.
2. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:
1. Comply with ANSI C12.20, Class 0.5.
2. Neutral Current Measurement: Not more than 0.65 percent.
3. Power Factor: 1.0 percent.
4. Frequency: 0.1 percent.
5. THD: 1.0 percent.
6. Waveform Sampling: 64 per cycle.

F. Data Link:
1. RS-485 Modbus, RTU protocol, 2-wire connection to host devices with a compatible port.

G. Meter Physical Characteristics:
1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values:
a. One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:
1) All meters.
2) Measurements.
3) THD.
4) Energy.
5) Demand.
6) Minimum and maximum values.
7) Power demand.

H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.

I. Meters:
   1. Instantaneous, rms:
      a. Current: Each phase, neutral and three-phase average.
      b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
      c. Active Power (kW): Each phase and three-phase total.
      d. Reactive Power (kVAR): Each phase and three-phase total.
      e. Apparent Power (kVA): Each phase and three-phase total.
      f. Power Factor: Each phase and three-phase total.
   2. Energy:
      a. Active Energy (kWh): Three-phase total.
   3. Demand, Derived from Instantaneous rms Meters:
      a. Current: Present and maximum.
      b. Active: Present and maximum.
      c. Reactive: Present and maximum.
      d. Apparent: Present and maximum.
   4. Power Quality Measurements:
      a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.

J. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics shall be 150 mA at 200 V.
   1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:
      a. User-defined pulse output, associated with kWh.
      b. User-defined pulse output, associated with kVARh.
   2. Power Supply: 120-V ac, 60 Hz.
   3. Circuit Connections:
      a. Voltage: Measurement autoranging, 60- to 400-V ac L-N. Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
      b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
      c. Frequency: 45 to 65 Hz.
      d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 POWER METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Schneider Electric USA, Inc.
   3. Siemens Industry, Inc., Energy Management Division.

B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.
   1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
   2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in non-air-conditioned spaces that have environmental controls to maintain ambient conditions of minus 13 to 158 deg F (minus 25 to plus 70 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
   2. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:
   1. Comply with ANSI C12.20, Class 0.5.
   2. Neutral Current Measurement: Not more than 0.65 percent.
   3. Power: 0.6 percent.
   4. Power Factor: 0.5 percent.
   5. Active Energy: 0.6 percent.
   6. Reactive Energy: 2.5 percent.
   7. Frequency: 0.05 percent.
   8. THD: 1.0 percent.
   9. Waveform Sampling: 32 per cycle.

F. Data Link:
   1. RS-485 Modbus RTU protocol, 2-wire connection.
      a. Provide for firmware and software updates through the communications port.

G. Meter Physical Characteristics:
   1. Display: Backlit LCD with antiglare and scratch-resistant lens.
   2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display shall include the following:
      a. All meters, including those listed under the following:
         1) Measurements.
         2) THD.
         3) Energy.
         4) Demand.
         5) Minimum and maximum values.
         6) Power demand.

H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 32 samples per cycle, simultaneously on all voltage and current channels of the meter.

I. Meters:
   1. Measurements: Instantaneous, in real time, rms to the 15th harmonic.
      a. Voltage: L-L each phase, L-N each phase, and three-phase average.
      b. Current: Each phase, three-phase average, and neutral.
      c. Unbalanced current, L-L V ac and L-N V ac.
      d. Active Power (+/- kW): Each phase and three-phase total.
      e. Reactive Power (+/- kVAR): Each phase and three-phase total.
      f. Apparent Power (+/- kVA): Each phase and three-phase total.
      g. Displacement Power Factor: Each phase and three-phase total.
      h. Distortion Power Factor: Each phase and three-phase total.
      i. Frequency.
   2. THD from measurements simultaneously from the same cycle, through 15th harmonic.
      a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
      b. Current THD: Each phase and three-phase average.
      c. Total demand distortion.

3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.
   a. Active kWh.
   b. Reactive kVARh.
   c. Apparent kVAh.
4. Demand: Present, last, predicted, peak.
   a. Three-phase average current.
   b. Three-phase total active power (kW).
   c. Reactive power (kVAR).
   d. Apparent power (kVA).
5. Minimum and Maximum Values:
   a. L-L and L-N voltages.
   b. Current in each phase.
   c. Power factor.
   d. Active power total.
   e. Reactive power total.
   f. Apparent power total.
   g. THD L-L and L-N voltages.
   h. THD current in each phase.
   i. Frequency.

J. Power Demand, User Selectable:
1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
   a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
   b. Fixed block that calculates demand at end of the interval.
   c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
3. Demand Calculation Initiated by a Synchronization Signal:
   a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
   b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
   c. Provide for synchronizing the demand with the internal of this instrument.

K. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.
1. Minimum and maximum of real-time rms measurement.
2. Energy.
3. Demand values.
4. Alarms, store the last 40 events.

L. Alarms: Transmit a digital output and show on display when alarmed. Provide for no fewer than 15 metered items. Each alarm shall be user configured, by using the following options:
1. Date and time stamp.
2. Enable-disable (default) or enable.
3. Pickup magnitude.
4. Pickup time delay.
5. Dropout magnitude.
6. Dropout time delay.
7. Alarm type.
8. Alarm label.

M. Output Signals: Provide two mechanical relays, rated not less than 250-V ac, 2-A resistive, and rated for 200-k cycles or more. The relays shall be user configurable in one of the following listed modes:
   1. Normal contact closure where the contacts change state for as long as the signal exists.
   2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
   3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.

N. Meter Face:
   1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
   2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
   3. Provide for the reset of metered peak values.
   4. Power Supply: 120-V ac, 60 Hz.
   5. Circuit Connections:
      a. Voltage: Measurements autoranging, 60- to 400-V ac L-N. Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
      b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
      c. Frequency: 45 to 65 Hz.
      d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.5 PC OPERATING SYSTEM SOFTWARE

A. Description: System software shall monitor, analyze, display, control, and save all the parameters and features available at the connected meter.

B. Software: Configured to run on a portable laptop computer, a single PC, or a tablet computer, with capability for accessing a single meter at a time, at the location of the meter. System is not connected to LAN.

C. Minimum Requirements:
   1. Real-time multitasking and multiuser 64-bit operating system that allows execution of multiple real-time programs and custom program development.
   2. Operating system shall be capable of operating Microsoft Windows applications.
   3. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

2.6 NETWORKED PC OPERATING SYSTEM SOFTWARE

A. Description: System software shall monitor, analyze, display, control, and save parameters and features available at each of the connected meters.

B. Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be web enabled.

C. System Software Minimum Requirements:
   1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple workstations operating and concurrent execution of multiple real-time programs and custom program development.
   2. Operating system shall be capable of operating Microsoft Windows applications.

3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

D. Operator Interface Software:
1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device, touchscreen, or mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from 1 to 60 minutes in 1-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity.
6. Security Access:
   a. Operator access to electrical monitoring and control system shall be under password control.
   b. An alphanumeric password shall be user assignable to each operator.
   c. Software shall have at least five access levels.
      1) View - View information. No change privileges allowed.
      2) User - Same as View, but is able to initiate control functions.
      3) Controller - Same as User, but is able to initiate communications.
      4) Operator - Same as Controller, but is able to modify configurations.
      5) Supervisor - Same as Operator, but is able to administer security privileges.
   d. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator-assigned access level(s) and menu-item access level(s) is required to gain access to menu item.
   e. Display menu items to operator with those menu items capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

E. Graphic Interface Software:
1. Include a full interactive graphical selection means of accessing and displaying system data to operator.
2. Descriptors for graphics, points, alarms, and such shall be modified through workstation under password control.
3. Display operator accessed data on the monitor.
4. Help Features: On-line context-sensitive help utility to facilitate operator training and understanding.

2.7 POWER MONITORING AND CONTROL SOFTWARE

A. Data Storage and Data Sharing:
1. Query and download logs of interval data stored on metering devices.
2. Query and download logs of alarm and event data stored on metering devices.
3. Query and download logs of waveform capture data stored on metering devices.
4. Query and download logs of interval data generated by the software and calculated by the meters.
5. Query and download logs of alarm and event data generated by the software and calculated by the meters.
6. Automatically re-arm the waveform recorders, on upload of information.
7. Provide a facility to archive, trim, and back up the database on demand, or on a schedule.

8. Provide a facility to view historical data from archived databases.
9. Support user changes to the database.
    a. Support on-line changes while the data storage/retrieval application is running.
    b. Suffer no interruption to its operation while changes are being made.
    c. Require no restart once the configuration has been performed.

B. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Site plan showing each building, and additional site elements, which are being controlled or monitored by the electrical power monitoring and control system.
2. Plan for each building floor, showing the following:
    a. Locations and identification of all monitored and controlled electrical equipment.
3. Control schematic for each device that is controlled by the meters of this Section, including a graphic system schematic representation with device identification.
4. Graphic display for each piece of equipment connected to the electrical monitoring and control system through a data link.
5. Electrical power monitoring and control system network riser diagram that shows schematic layout for entire system including meters, other network devices.

2.8 NETWORK CONFIGURATION SOFTWARE

A. Network Management Graphical Interface Features:
1. Add and remove devices in the power monitoring and control network.
2. Application for naming devices based on a user-defined naming scheme.
3. Add and remove I/O servers in the power monitoring and control network.
4. Edit communication properties for devices including timeouts and delays.
5. Display mandatory fields when adding a new device.
6. Allow to manually connect and disconnect serial, Ethernet, modem, and Ethernet gateway sites.
7. Enable and disable devices and sites in the power monitoring and control network without interruption to other devices or sites.
8. Pool modem resources so that the software uses any available modem.
9. Monitor the following diagnostics:
    a. Communication request/response and error rates, and timeouts.
    b. Log acquisition services.

B. Database Maintenance Features:
1. Backup, archive, and trim data, event, and waveform logs.
    a. Record start and end date for operation.
    b. Allow copying data to another database.
    c. Be capable of selecting any or all of the logs specified for the meters that are Work of this Section.
        1) Data logs.
        2) Event logs.
        3) Waveform logs.

C. Web Reporter: Allow viewing historical data in preformatted report templates via a web browser.
1. Features:
    a. User-configurable report generator to trigger on event, based on a schedule, or manual initiation.
    b. Format reports in HTML, PDF, TIF, Excel, XML, or user-selected printer, or network folder.
    c. Distribution of reports via email.
2. Report on power and demand profiles.
3. Power quality report with CBEMA evaluation.
4. EN 50160 compliance report.
5. 100-ms PQ report.

6. Energy over Period Report:
   a. User-defined rollup interval by day, week, month, or year.
   b. Compare daily energy to the following:
      1) Previous day.
      2) Same day, previous week.
      3) Same day, previous month.
      4) User-defined specific day.
   c. Compare weekly energy to the following:
      1) Previous week.
      2) Same week from previous month.
      3) Same week from previous year.
      4) User-defined specific week.
   d. Compare monthly energy to the following:
      1) Previous month.
      2) Same month from previous year.
      3) User-defined specific month.
   e. Compare annual energy to the following:
      1) Previous year.
      2) User-defined specific year.
7. Energy by daily period report for the user-defined periods. Aggregate consumption of the periods by the day, week, and year.
8. Tabular Report: Show values for multiple measurements and measurements from multiple devices in tabular format.
9. Trend Report:
   a. Show values for multiple measurements and measurements from multiple devices in any of the following graphical formats:
      1) Line chart.
      2) Pie graph.
      3) Bar chart.
      4) Column chart.
      5) Smooth line chart.
      6) Stacked column chart.
      7) Stacked bar chart.
10. Alarm and Event History: User formatted, based on the meters and priority; and with user-defined alarm and event reports.
11. System Configuration Report:
    a. Device name.
    b. Device type.
    c. Device address.
    d. Connection status.
    e. Device protocol.
    f. Device description.
12. Each default report shall include the following:
    a. Summary aggregation of data from the selected devices.
    b. Individual device information.
    c. Raw data.
13. The reporting tool shall provide a graphical interface to create and manage multiple Time of Use schedules:
    a. Tariffs including energy cost rates per kWh, kVARh, and kVAh, and demand charges per kW, kVAR, and kVA.
    b. Off-peak and on-peak times.

2.9 SYSTEM OPERATOR INTERFACES

A. Operator means of system access shall be through the following:
   1. Desktop workstation with hardwired connection through LAN port.
   2. Portable terminal with hardwired connection through LAN port at each meter.
   3. Remote connection using outside of system PC, tablet, or phone using an internet portal.

2.10 DESKTOP WORKSTATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Dell Inc.
   2. HP.

B. Performance Requirements:
   1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
   2. Capable of running Microsoft Windows.
   3. ENERGY STAR compliant.

C. Personal Computer:
   1. Minimum Processor Speed: , Core i3.
   2. RAM:
      a. Capacity: 4 GB.
      b. Speed and Type: 1333 MHz,.
   3. Primary Hard Drive:
      a. Media: Hybrid solid-state and rotating disc.
      b. Number of Hard Drives: Two.
      c. Capacity: 1TB.
   4. Expansion Slots: Minimum of 4, 64 bit.
   5. Video Card:
      a. Capable of supporting two monitors.
      b. Resolution: 1920 by 1200 pixels minimum for each monitor.
      c. RAM: 2 GB.
   6. Sound Card:
      a. At least 128 voice wavetable synthesis.
      b. Capable of delivering three-dimensional sound effects.
      c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
   7. Network Interface Card: Include card with connection, as applicable.
      a. 10-100-1000 base TX Ethernet with RJ45 connector port.
      b. 100 base FX Ethernet with SC or ST port.
   8. Wireless Ethernet, 802.11 a/b/g/n.
   9. Optical Modem: Full duplex link for connection to optical fiber cable provided.
   10. I/O Ports:
      a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
      b. One serial port.
      c. One parallel port.
      d. Two PS/2 ports.
      e. One RJ-45.
      f. One stereo line-in and line-out on back panel.
      g. One microphone and headphone connector on front panel.
      h. One IEEE 1394 on front and back panel with PCI-e card.
      i. One ESATA port on back panel.
   11. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

D. Keyboard:
1. 101-key enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

E. Pointing Device:
1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

F. Flat Panel Display Monitor:
1. Number of Displays: Two.
a. Display Support: Individual tilt adjustable base.
2. Color display with 27 diagonal viewable area.
3. Aspect Ratio: 16 to 9.
4. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
5. Digital input signal.
6. Response Time: 5ms.
7. Dynamic Contrast Ratio: 50000 to 1.
8. Brightness: 250 cd/sq. m.
9. ENERGY STAR compliant.
10. Antiglare display.

G. Speakers:
1. Two, with individual controls for volume, bass, and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

H. I/O Cabling: Include applicable cabling to connect I/O devices.

I. Software:
1. Factory-installed operating system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

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

3.2 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

C. 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.

D. Wiring and Cabling Installation:
1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring.

E. Raceways Installation:
1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
2. Comply with Section 270528 "Pathways for Communications Systems" for control wiring, RS-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

F. Identification Installation:
1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 271513 "Communications Copper Horizontal Cabling" for identification products and cable management system requirements for twisted pair cable, RS-485 cable, low-voltage control cable, and RS-232 cable.
3. Comply with Section 271523 "Communications Optical Fiber Horizontal Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.3 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:
1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex electrical power receptacle.
3. Install software on workstation(s) and verify that software functions properly.
4. Develop Project-specific graphics, trends, reports, logs, and historical database.
5. Power workstation through a UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:
1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify that software functions properly.

C. Graphics Application:
1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy to include in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of the system operation and maintenance manual.

3.4 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.5 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

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 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. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
   3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
   5. 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 IEC 61280-4-1.
         2) Attenuation test results for links shall be less than 2.0 dB.
      c. 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.
   6. Power Monitoring and Control System Tests.
      a. Test Analog Signals:
         1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
         2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
         3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
      b. Test Digital Signals:
         1) Check digital signals using a jumper wire.
         2) Check digital signals using an ohmmeter to test for contact making or breaking.

c. I/O Control Loop Tests:
   1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
   2) Test every I/O point throughout its full operating range.
   3) Test every control loop to verify that operation is stable and accurate.
   4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
   5) Test and adjust every control loop for proper operation according to sequence of operation.
   6) Test software and hardware interlocks for proper operation.
   7) Operate each analog point at the following:
      a) Upper quarter of range.
      b) Lower quarter of range.
      c) At midpoint of range.
   8) Exercise each binary point.
   9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument shall match.
   10) Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

D. Wiring and cabling will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 FINAL REVIEW

A. Submit written request to Architect when the power monitoring and control system is ready for final review. Written request shall state the following:
   1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
   2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
   3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
   4. The system is complete and ready for final review.

B. Review by Architect will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

3.8 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include semiannual preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required

for proper system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 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 15 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain the power monitoring and control system.

B. Extent of Training:
   1. Base extent of training on scope and complexity of power monitoring and control system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
   2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
   3. Minimum Training Requirements:
      a. Provide no fewer than two days of training total.
      b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
      c. Total days of training shall be broken into not more than four separate training classes.
      d. Each training class shall be no fewer than one consecutive day(s).

C. Attendee Training Manuals:
   1. Provide each attendee with a color hard copy of all training materials and visual presentations.
   2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
   3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

D. Instructor Requirements:
   1. One or multiple qualified instructors, as required, to provide training.
   2. Instructors shall have no fewer than five years of providing instructional training on no fewer than five past projects with similar electrical monitoring and control system scope and complexity.

E. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.

F. On-Site Training:
   1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.

2. Instructor shall provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. The workstation provided with the system shall be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.

G. Off-Site Training:
1. Provide conditioned training rooms and workspace with ample tables, chairs, power, and data connectivity for each attendee.
2. Provide capability to remotely access to Project monitoring and control system for use in training.
3. Provide a workstation for use by each attendee.

3.11 AT COMPLETION OF TRAINING:

A. Staff familiar with the system installed are capable of demonstrating operation of the system during final review.

B. Demonstration shall include, but not be limited to, the following:
1. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
2. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
3. Trends, summaries, logs, and reports set-up for Project.
4. Software's ability to communicate with controllers, workstations, and uploading and downloading of control programs.
5. Software's ability to edit control programs off-line.
6. Data entry to show Project-specific customizing capability including parameter changes.
7. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
8. Execution of digital and analog commands in graphic mode.
9. Spreadsheet and curve plot software and its integration with database.
10. Online user guide and help functions.
11. For Each Meter:
    a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
    b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
    c. Wiring Labels: Match control drawings.
    d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
    e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
12. For Each Workstation:
    a. I/O point lists agree with naming conventions.
    b. Graphics are complete.
    c. UPS unit, if applicable, operates.

END OF SECTION 260913

SECTION 260923

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy sensors.
6. Digital timer light switches.
7. Lighting contactors.
8. Emergency shunt relays.

B. Related Requirements:
1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Show installation details for the following:
a. Occupancy sensors.
b. Vacancy sensors.
2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, 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 equipment will be attached.
3. Items penetrating finished ceiling, including the following:
a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Control modules.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On manufacturer's website. Provide names, versions, and website addresses for locations of installed software.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control software.
      b. Faulty operation of lighting control devices.
   2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Manufacturing Co., Inc.
   2. Lithonia Lighting; Acuity Brands Lighting, Inc.
   3. Lutron Electronics, Inc.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.
   1. Listed and labeled as defined in NFPA 70 and marked for intended location and application.
   2. Contact Configuration: SPST.
   3. Contact Rating: 30-A inductive or resistive, 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. Programs: Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
   6. Automatic daylight savings time changeover.
   7. 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: 30-A inductive or resistive, 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Manufacturing Co., Inc.

2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Lutron Electronics, Inc.

B. Description: Solid state; one set of NO dry contacts rated for 24 V dc at 1 A, to operate connected load, complying with UL 773, and compatible with power pack, lighting control panelboard.
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 (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Mounting: 1/2-inch (13-mm) threaded male conduit.
5. Failure Mode: Luminaire stays ON.
6. Power Pack: Dry contacts rated for 20-A LED 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.
a. LED status lights to indicate load status.
b. Plenum rated.

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Leviton Manufacturing Co., Inc.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Lutron Electronics, Inc.

B. 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 power pack mounted on luminaire, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:
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 luminaires. Sensor is powered by controller unit.
3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).

E. Power Pack: Dry contacts rated for 20-A LED 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.
1. LED status lights to indicate load status.
2. Plenum rated.

F. Power Pack: Digital controller capable of accepting 3 RJ45 inputs with one outputs rated for 20-A incandescent LED load at 120- and 277-V ac, for 16-A LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
1. With integral current monitoring
a. Compatible with digital addressable lighting interface.
1) Plenum rated.

2.4 INDOOR OCCUPANCYAND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Manufacturing Co., Inc.
   2. Lithonia Lighting; Acuity Brands Lighting, Inc.
   3. Lutron Electronics, Inc.

B. General Requirements for Sensors:
   1. Wall Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
   2. Dual technology.
   3. Separate power pack.
   4. Hardwired connection to switch.
   5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   6. Operation:
      a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
      b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
      c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
   8. Power: Line voltage.
   9. Power Pack: Dry contacts rated for 20-A LED 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.
   10. Mounting:
      a. Sensor: Suitable for mounting in any position on a standard outlet box.
      b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
      c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
   12. Bypass Switch: Override the "on" function in case of sensor failure.
   13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

C. Dual-Technology Type: Wall 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- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
   3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
   4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet (110 square meters) when mounted48 inches (1200 mm) above finished floor.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Manufacturing Co., Inc.
   2. Lithonia Lighting; Acuity Brands Lighting, Inc.
   3. Lutron Electronics, Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
   4. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor:
   1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
   2. Sensing Technology: Dual technology - PIR and ultrasonic.
   3. Switch Type: SP, manual "on," automatic "off."
   4. Capable of controlling load in three-way application.
   5. Voltage: Dual voltage - 120 and 277 V.
   6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
   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.
   9. Color: White.
   10. Faceplate: Color matched to switch.

2.6 DIGITAL TIMER LIGHT SWITCH

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Manufacturing Co., Inc.
   2. Lithonia Lighting; Acuity Brands Lighting, Inc.
   3. Lutron Electronics, Inc.

B. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 10 minute increments.
   1. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 amps at 277-V ac for LED, and 1/4 horsepower at 120-V ac.
   2. Integral relay for connection to BAS.
   3. Voltage: Dual voltage - 120 and 277 V.
   4. Color: White.
   5. Faceplate: Color matched to switch.

2.7 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ASCO: a brand of Vertiv.
   2. Eaton.
   3. Square D.

B. Description: Electrically operated and mechanically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
   1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
   2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
   3. Enclosure: Comply with NEMA 250.
   4. Provide with control and pilot devices as scheduled, matching the NEMA type specified for the enclosure.

2.8 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 than No. 16 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. 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.

C. 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.

3.3 CONTACTOR INSTALLATION

A. Comply with NECA 1.

3.4 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

C. Wiring within Enclosures: Comply with NECA 1. 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.

3.5 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.

3.6 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.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
   1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
   2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
   3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 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 15 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."

B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 260936

MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Wall-box, multiscene, modular dimming controls.
2. Multipreset modular dimming controls.

1.2 DEFINITIONS

A. BAS: Building automation system.

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. Low Voltage: As defined in NFPA 70, the term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.

D. RFI: Radio-frequency interference.

E. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

F. SCR: Silicon-controlled rectifier.

G. Zone: A luminaire or group of luminaires controlled simultaneously as a single entity. Also known as a "channel."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
2. Device plates and plate color and material.
3. Ballast and lamp combinations compatible with dimmers.
4. Sound data including results of operational tests of central dimming controls.
5. 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.
3. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
4. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
5. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.

6. 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 used. Describe characteristics of network and other data communication lines.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For standalone multipreset modular dimming controls 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.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multipreset modular 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Leviton Manufacturing Co., Inc.
   2. Lightolier; a Philips group brand.
   3. Lutron Electronics Co., Inc.

2.2 SYSTEM DESCRIPTION

A. Compatibility:
   1. Dimming control components shall be compatible with luminaires.
   2. Dimming control devices shall be compatible with lighting control system components specified in Section 260923 "Lighting Control Devices."

B. Dimmers and Dimmer Modules: Comply with UL 508.
   1. Audible Noise and RFI Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules shall include integral or external filters to suppress audible noise and RFI.
   2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

C. Capacities: Unit shall be rated for 2400 W at 240-V ac and 2000 W at 120-V ac for up to 100 devices or zones.

D. Surge Protection: Withstand supply power surges without impairment to performance.
1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.

E. Off Control Position: User-selected off position of any control point shall disconnect the load from line supply.

F. 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.

2.3 WALL-BOX MULTISCENE DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in multigang wall box under a single wall plate. Each zone shall be adjustable to indicated number of scenes, which shall reside in the memory of zone controller.

B. Dimmers: Each zone shall be configurable to control the following loads:
1. LED lamps.

C. Dimmers: Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of rms voltage.

D. Memory:
1. Retain preset scenes and fade rates through momentary (up to 3-second) power interruptions.
2. Retain preset scenes through power failures for at least seven days.

E. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices." Master-control cover plate shall be one piece.

F. Master controller shall include the following:
1. Cover-mounted switches, including master off, all bright, and selectors for each scene.
2. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
3. Concealed switches and indicators for specified function.
4. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
5. Fade time indicated by digital display for current scene while fading.
6. Cover-mounted infrared receiver.

2.4 MULTIPRESET MODULAR DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of the following:
1. Master controller.
2. Dimmer panels, and indicated number of zone stations.
3. Controls and dimmers shall be integrated for mounting in a multigang wall box under a single wall plate.
4. Each zone shall be adjustable to indicated number of scenes, which shall reside in the memory of zone controller.

B. Dimmers: Each zone shall be configurable to control the following loads:
1. LED lamps.

C. Dimmers: Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of rms voltage.

D. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.

E. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices." Master-control cover plate shall be one piece.

F. Master controller shall include the following:
1. Wall-box style, single coverplate supplied by manufacturer.
2. Cover-mounted switches, including master off, all bright, and selectors for each scene.
3. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
4. Concealed switches and indicators for specified function.
5. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
6. Fade time indicated by digital display for current scene while fading.
7. Cover-mounted infrared receiver.

G. Remote-Control Stations:
1. Numbered push buttons to select scenes.
2. Off switch to turn master station off.
3. On switch turns all scenes of master station to full bright.
4. Control Wiring: NFPA 70, Class 2.
5. Mounting: Single flush wall box with manufacturer's standard faceplate.

H. Dimmer Panels: Modular, plug-in type, complying with UL 508.
1. Integrated Short-Circuit Rating: 10 kA at 120 V.
2. Dimmers:
a. Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
b. Dimming Curve: Modified "square law" as specified in IES's "Lighting Handbook"; control voltage is 0- to 10-V dc.
c. Dimming Range: Zero to 100 percent, full output voltage not less than 98 percent of line voltage.
d. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of rms voltage.

I. Circuit Breakers: Complying with UL 489 and classified as switch duty.

2.5 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. Class 2 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."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).

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.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

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 modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

D. Dimming control components will be considered defective if they do not pass tests and inspections.

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 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls. Laptop portable computer shall be used in training.

END OF SECTION 260936

SECTION 262413

SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Service and distribution switchboards rated 600 V and less.
2. Control power.
3. Accessory components and features.

B. Related Requirements
1. Section 260574 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.2 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. Detail utility company's metering provisions with indication of approval by utility company.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. 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.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Delegated Design Submittal:
1. For arc-flash hazard analysis.
2. For arc-flash labels.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: 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.

B. 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.

1.4 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.

1.5 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. 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.

1.6 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: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 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.

1.8 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 (40 deg C).
      b. Altitude: Not exceeding 6600 feet (2000 m).

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Owner no fewer than 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 Owner's written permission.
   4. Comply with NFPA 70E.

1.9 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.

1.10 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Siemens Industry, Inc., Energy Management Division.
   3. Square D; by Schneider Electric.
   4. General Electric, by ABB

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- and Side-Accessible Switchboards:
   1. Main Devices: Fixed, individually mounted.
   2. Branch Devices: Panel mounted.
   3. Section Alignment: Front and Rear aligned.

I. Nominal System Voltage: 208Y/120 V.

J. Main-Bus Continuous: 2500 A.

K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Seismic Controls for Electrical Systems."
   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.
      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."

L. Indoor Enclosures: Steel, NEMA 250, Type 1.

M. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

N. Barriers: Between adjacent switchboard sections.

O. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

P. 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.

Q. 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.

R. 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.

S. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

T. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

U. 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: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
3. Tin-plated aluminum feeder circuit-breaker line connections.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical 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- (6-by-50-mm-) hard-drawn copper of 98 percent conductivity, equipped with mechanical 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 mechanical 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.

V. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

W. 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.

2.3 CONTROL POWER

A. Control Circuits: 120-V ac, supplied from remote branch circuit.

2.4 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

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 (100-mm) 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 (50-mm) 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 (450-mm) 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: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:
   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.

F. Switchboard will be considered defective if it does not pass tests and inspections.

G. 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 indicated.

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. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413

SECTION 262416

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. Load centers.

1.2 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.

1.3 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.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards.

1.5 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.

1.6 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. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and GFEP Types: six 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.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.8 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.

1.9 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 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
      b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).

1.10 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: Ten 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 Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
      d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   2. Height: 84 inches (2.13 m) maximum.
   3. 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.
   4. Finishes:
      a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: 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: Tin-plated aluminum.
      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. 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.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Tin-plated aluminum.
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: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical 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. 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: 20 percent.

K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
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.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
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 2.

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Siemens Industry, Inc., Energy Management Division.
   3. Square D; by 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 (914 mm) high, provide two latches, keyed alike.

D. Mains: Circuit breaker, Lugs only.

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.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Siemens Industry, Inc., Energy Management Division.
   3. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically 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: 120-V branch circuit.

F. 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 LOAD CENTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Siemens Industry, Inc., Energy Management Division.
   3. Square D; by Schneider Electric.

B. Load Centers: Comply with UL 67.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges secured with flush latch with tumbler lock; keyed alike.

F. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

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 (2286 mm) 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. 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.

K. 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.

L. Install filler plates in unused spaces.

M. Stub four 1-inch (25 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (25 mm) empty conduits into raised floor space or below slab not on grade.

N. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

O. Mount spare fuse cabinet in accessible location.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. 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. 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.

3.4 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 indicated.

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.

3.5 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 262713

ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes
   1. Meter Sockets.
   2. Modular Meter Centers.

1.2 DEFINITIONS

A. KY or KYZ Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity (kWh) that is based on a relay opening and closing in response to the rotation of the disk in the meter. Electronic meters generate pulses electronically.

1.3 ACTION SUBMITTALS

A. Product Data:
   1. For each type of meter.
   2. For metering infrastructure components.

B. Shop Drawings: For electricity-metering equipment.
   1. Include elevation views of front panels of control and indicating devices and control stations.
   2. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
   3. Include series-combination rating data for modular meter centers with main disconnect device.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1. Application and operating software documentation.
   2. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of metering equipment 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.

1.8 COORDINATION

A. Electrical Service Connections:
   1. Coordinate with utility companies and utility-furnished components.
      a. Comply with requirements of utility providing electrical power services.
      b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

A. Install metering accessories furnished by the utility company, complying with its requirements.

B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by the Utility.
   1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."

C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

D. Meter Sockets:
   1. Comply with requirements of electrical-power utility company.
   2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

E. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with lugs only, wireways, meter socket modules, and feeder circuit breakers arranged in adjacent vertical sections complete with interconnecting buses.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton.
      b. Siemens Industry, Inc., Energy Management Division.
      c. Square D; by Schneider Electric.
   2. Comply with requirements of utility company for meter center.
      a. Comply with UL 67.
   3. Housing: NEMA 250, Type 1 enclosure.
   4. Meter Socket Rating: Coordinated with connected feeder circuit rating.
   5. Minimum Short-Circuit Rating: 42,000 A symmetrical at rated voltage.
   6. Steady-state and short-circuit current ratings shall have ratings that match connected circuit ratings.

7. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers and having an adjustable magnetic trip setting for circuit-breaker frame sizes of 250 A and larger. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Circuit breakers shall be operable from outside the enclosure to disconnect the unit. Configure cover so it can be opened only when the disconnect switch is open.
8. Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect downstream circuit breakers and to house load centers and panelboards that have 42,000A interrupting capacity.
    a. Identification: Complying with requirements in Section 260553 "Identification for Electrical Systems."
    b. Physical Protection: Tamper resistant, with hasp for padlock.
9. Surge Protection for Main Disconnect: Factory installed, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

F. Arc-Flash Warning Labels;
1. Labels: Comply with requirements for "Arc-Flash Warning Labels" in Section 260574 "Arc-Flash Studies." Apply a 3-1/2-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.
2. Labels: Comply with requirements for "Self-Adhesive Equipment Labels" and "Signs" in Section 260553 "Identification for Electrical Systems." Apply a 3-1/2-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.
    a. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to switchboard installation requirements in NECA 400.

D. Install arc-flash labels as required by NFPA 70.

E. 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 271513 "Communications Copper Horizontal Cabling."
3. Minimum conduit size shall be 1/2 inch (13 mm).

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
   1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.
   2. Equipment Identification Labels: Self-adhesive labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card with occupant's name.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Prepare test and inspection reports.

END OF SECTION 262713

SECTION 262726

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Standard-grade receptacles, 125 V, 15A & 20A.
2. USB receptacles.
3. GFCI receptacles, 125 V, 20 A.
4. Twist-locking receptacles.
5. Pendant cord-connector devices.
6. Cord and plug sets.
7. Toggle switches, 120/277 V, 15A & 20A.
8. Decorator-style devices, 15A & 20A.
9. Residential devices.
10. Wall-box dimmers.
11. Wall plates.
12. Floor service fittings.
13. Poke-through assemblies.
14. Prefabricated multioutlet assemblies.

1.2 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 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.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices for Owner-Furnished Equipment:
   1. Receptacles: Match plug configurations.
   2. Cord and Plug Sets: Match equipment requirements.

F. Device Color:
   1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

G. Wall Plate Color: For plastic covers, match device color.

H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498 and FS W-C-596.

B. Tamper-Resistant Duplex Receptacles, 125 V, 20 A
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498 and FS W-C-596.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Weather-Resistant Duplex Receptacle, 125 V, 20 A :
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498.
5. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 STANDARD-GRADE RECEPTACLES, 125 V, 15 A

A. Duplex Receptacles, 125 V, 15 A :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour)
   d.
2. Description: Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Standards: Comply with UL 498 and FS W-C-596.

B. Tamper-Resistant Duplex Receptacles, 125 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour)
2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Standards: Comply with UL 498 and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Weather-Resistant Duplex Receptacle, 125 V, 15 A :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour)
2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Standards: Comply with UL 498.
5. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.4 USB RECEPTACLES

A. USB Charging Receptacles
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.

3. USB Receptacles: Dual, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. Standards: Comply with UL 1310 and USB 3.0 devices.

B. Tamper-Resistant Duplex and USB Charging Receptacles :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.
3. Line Voltage Receptacles: Two pole, three wire, and self-grounding; NEMA WD 6, Configuration 5-20R.
4. USB Receptacles: Dual USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
5. Standards: Comply with UL 498, UL 1310, USB 3.0 devices, and FS W-C-596.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.5 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498 and UL 943 Class A.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.6 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, 120 V, 20 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Configuration: NEMA WD 6, Configuration L5-20R.
3. Standards: Comply with UL 498.

B. Twist-Lock, Single Receptacles, 250 V, 20 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Premise Wiring.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Configuration: NEMA WD 6, Configuration L6-20R.
3. Standards: Comply with UL 498.

2.7 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Premise Wiring.
2. Leviton Manufacturing Co., Inc.
3. Pass & Seymour/Legrand (Pass & Seymour).

C. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R.

D. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

E. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

F. Standards: Comply with FS W-C-596.

2.8 CORD AND PLUG SETS

A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.9 TOGGLE SWITCHES, 120/277 V, 15 A

A. Single-Pole Switches, 120/277 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour/Legrand (Pass & Seymour).
2. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour/Legrand (Pass & Seymour).
2.
3. Comply with UL 20 and FS W-S-896.
4. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
5. Standards: Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour/Legrand (Pass & Seymour).
2. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour/Legrand (Pass & Seymour).
2.
3. Standards: Comply with UL 20 and FS W-S-896.

E. Pilot-Light, Single-Pole Switches: 120/277 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Illuminated when switch is off.
3. Standards: Comply with UL 20 and FS W-S-896.

F. Lighted Single-Pole Switches, 120/277 V, 15 A
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hubbell Incorporated; Wiring Device-Kellems.
b. Leviton Manufacturing Co., Inc.
c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Handle illuminated when switch is off.
3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

G. Key-Operated, Single-Pole Switches, 120/277 V, 15 A
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
      d.
   2. Description: Factory-supplied key in lieu of switch handle.
   3. Standards: Comply with UL 20 and FS W-S-896.

H. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: For use with mechanically held lighting contactors.
   3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

I. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
   3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.10 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Standards: Comply with UL 20 and FS W-S-896.

E. Pilot-Light, Single-Pole Switches: 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Illuminated when switch is off.
   3. Standards: Comply with UL 20 and FS W-S-896.

F. Lighted Single-Pole Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Handle illuminated when switch is off.
   3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

G. Key-Operated, Single-Pole Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2.
   3. Description: Factory-supplied key in lieu of switch handle.
   4. Standards: Comply with UL 20 and FS W-S-896.

H. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: For use with mechanically held lighting contactors.
   3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

I. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: For use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
   3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.11 DECORATOR-STYLE DEVICES, 15 A

A. Decorator Duplex Receptacles, 125 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-15R.
   4. Standards: Comply with UL 498.

B. Decorator, Tamper-Resistant, Duplex Receptacles, 125 V, 15 A,:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-15R.
   4. Standards: Comply with UL 498.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-15R.
   4. Standards: Comply with UL 498.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches,120/277 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Square face illuminated when circuit is switched off.
   3. Standards: Comply with UL 20.

2.12 DECORATOR-STYLE DEVICES, 20 A

A. Decorator Duplex Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498.

B. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   3. Configuration: NEMA WD 6, Configuration 5-20R.
   4. Standards: Comply with UL 498.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches,120/277 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Square face illuminated when circuit is switched off.
   3. Standards: Comply with UL 20.

2.13 RESIDENTIAL DEVICES

A. Residential-Grade, Tamper-Resistant, GFCI Receptacles, 125 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Premise Wiring.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Feed-through connectors.
   4. Standards: Comply with UL 943 and UL 1699.

B. Residential-Grade, Tamper-Resistant, AFCI Receptacles, 125 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Premise Wiring.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Feed-through connectors.
   4. Standards: Comply with UL 943 and UL 1699.

C. Residential-Grade, Tamper-Resistant Receptacles, 125 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Premise Wiring.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Feed-through connectors.
   4. Standards: Comply with UL 498.

D. Weather- and Tamper-Resistant Receptacles, 125 V, 15 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Premise Wiring.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Feed-through connectors.
   4. Standards: Comply with UL 498.
   5. Marked as "Weather Resistant."

E. Fan-Speed Controls:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Premise Wiring.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Modular, 120-V ac, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters.
   3. Standards: Comply with UL 1917.
   4. Continuously adjustable toggle switch, 1.5 A.
   5. Three-speed adjustable rotary knob, 1.5 A.

F. Telephone Outlet:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Leviton Manufacturing Co., Inc.
2. Description: Single RJ-11 jack for terminating Category 3, balanced twisted pair cable complying with Section 271513 "Communications Copper Horizontal Cabling."
3. Standards: Comply with UL 1863.

G. Combination Telephone and Coaxial Outlet:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Leviton Manufacturing Co., Inc.
2. Description: Single RJ-11 jack for terminating Category 3, twisted pair cable complying with Section 271513 "Communications Copper Horizontal Cabling" and a single BNC connector for terminating coaxial cable complying with Section 271533 "Communications Coaxial Horizontal Cabling."
3. Standards: Comply with UL 1863.

2.14 DIMMERS

A. Wall-Box Dimmers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
3. Control: Continuously adjustable slider; with single-pole or three-way switching.
4. Standards: Comply with UL 1472.
5. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
   a. 600 W; dimmers shall require no derating when ganged with other devices.
6. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.15 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. 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: Smooth, high-impact thermoplastic 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant thermoplastic with lockable cover.

2.16 FLOOR SERVICE FITTINGS

A. Flush-Type Floor Service Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Premise Wiring.
   b. Wiremold / Legrand.
2. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.
3. Compartments: Barrier separates power from voice and data communication cabling.
4. Service Plate and Cover: Rectangular, die-cast aluminum with satin finish.
5. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
6. Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."

B. Flap-Type Service Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Premise Wiring.
   b. Thomas & Betts Power Solutions; ABB Group.
2. Description: Type: Modular, flap-type, dual-service units suitable for wiring method used, with flaps flush with finished floor.
3. Compartments: Barrier separates power from voice and data communication cabling.
4. Flaps: Rectangular, die-cast aluminum with satin finish.
5. Service Plate: Same finish as flaps.
6. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
7. Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."

C. Above-Floor Service Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Premise Wiring.
   b. Thomas & Betts Corporation; A Member of the ABB Group.
   c. Wiremold / Legrand.
2. Description: Type: Modular, above-floor, dual-service units suitable for wiring method used.
3. Compartments: Barrier separates power from voice and data communication cabling.
4. Service Plate: Rectangular, die-cast aluminum with satin finish.
5. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
6. Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."

2.17 POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.

2. Pass & Seymour/Legrand (Pass & Seymour).
3. Wiremold / Legrand.

C. Standards: Comply with scrub water exclusion requirements in UL 514.

D. Service-Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks, complying with requirements in Section 271513 "Communications Copper Horizontal Cabling."

E. Size: Selected to fit nominal 4-inch (100-mm) cored holes in floor and matched to floor thickness.

F. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

G. Closure Plug: Arranged to close unused 4-inch (100-mm) cored openings and reestablish fire rating of floor.

H. 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 271513 "Communications Copper Horizontal Cabling."

2.18 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Description: Two-piece surface metal raceway, with factory-wired multioutlet harness.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold / Legrand.

C. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

D. Raceway Material: PVC.

E. Multioutlet Harness:
1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: 18 inches (460 mm).
3. Wiring: No. 12 AWG solid, Type THHN copper, single circuit or two circuit, connecting alternating receptacles.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Application:
1. All receptacles in Back of House Areas including workrooms, staff areas and offices shall be standard style.
2. In commercial spaces such as Lobby, leasing, amenities, utility spaces and all corridors and common areas, provide commercial grade receptacles;
3. Residential grade receptacles may be used in the residential units only.

C. 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.

D. 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 comply with 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.

E. 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 (152 mm) 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.

F. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

G. 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.

H. 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.

I. 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.

J. 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 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. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for 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.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813

FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600 V ac and less for use in the following:
      a. Enclosed controllers.
      b. Enclosed switches.
   2. Spare-fuse cabinets.

1.2 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. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   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. Submit in PDF format.
   4. Coordination charts and tables and related data.
   5. Fuse sizes for elevator feeders and elevator disconnect switches.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," Section 017823 "Operation and Maintenance Data," include the following:
   1. Current-limitation curves for fuses with current-limiting characteristics.
   2. 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 PDF format.
   3. Coordination charts and tables and related data.

1.4 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.

1.5 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bussmann, an Eaton business.
   2. 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: 600-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 J: 600-V, zero- to 600-A rating, 200 kAIC.
   4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC.

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- (38-mm-) 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 RK1, time delay.
   2. Feeders: Class RK5, time delay.
   3. Motor Branch Circuits: Class RK5, 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 J, time delay.
   7. 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 262816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers (MCCBs).
5. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, 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 a nationally recognized testing laboratory (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.

B. Shop Drawings: For enclosed switches and circuit breakers.
1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for enclosed switches and 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.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers 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 enclosed switches and circuit breakers.
      b. 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. Provide in PDF electronic format.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 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."

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. 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.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Siemens Industry, Inc., Energy Management Division.
   3. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:
   1. Double throw.
   2. Three pole.

3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Siemens Industry, Inc., Energy Management Division.
3. Square D; by Schneider Electric.

B. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. Service-Rated Switches: Labeled for use as service equipment.

2.5 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bussmann, an Eaton business.
2. Littelfuse, Inc.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 600-V ac, 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 600-V ac, 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

E. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

F. Accessories:
1. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
2. Form C alarm contacts that change state when switch is tripped.
3. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
4. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
5. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
6. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
7. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
8. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V dc.
9. Hookstick Handle: Allows use of a hookstick to operate the handle.
10. Lugs: Mechanical type, suitable for number, size, and conductor material.
11. Service-Rated Switches: Labeled for use as service equipment.

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Siemens Industry, Inc., Energy Management Division.
3. Square D; by Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be. Circuit breaker/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below 167 deg F (75 deg C) rated wire.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal 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.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

O. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical 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; remote-mounted and 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. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
   6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   8. 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.
   9. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
   10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   11. Zone-Selective Interlocking: Integral with ground-fault trip unit; for interlocking ground-fault protection function.
   12. Electrical Operator: Provide remote control for on, off, and reset operations.
   13. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac.

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 3R.
   3. Kitchen 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.

3.3 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections for Switches:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, grounding, and clearances.
      c. Verify that the unit is clean.
      d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
      e. Verify that fuse sizes and types match the Specifications and Drawings.
      f. Verify that each fuse has adequate mechanical support and contact integrity.
      g. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
            a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
      h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
      i. Verify correct phase barrier installation.
      j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's

published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify that the unit is clean.

e. Operate the circuit breaker to ensure smooth operation.

f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.

h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. 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.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.
1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List 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 "Coordination Studies."

END OF SECTION 262816

SECTION 263100

PHOTOVOLTIC COLLECTORS

PART 1 - GENERAL

1.1 SCOPE

A. The Contractor shall design, furnish and install the photovoltaic system as specified herein and as contained within the contract specifications and shown on the contract drawings.

B. The information shown on the drawings is for general information only to assist the Contractor in preparing his bid. The Contractor is responsible for providing a complete design-build photovoltaic system.

C. The Contractor must submit a complete system design to AHJ and Utility for approval.

D. The Contractor is responsible for submitting all documentation required for city, state, and federal tax incentives for the photovoltaic power system.

1.2 1.3 REFERENCES

A. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA, ANSI, NEC, UL and ETL.

B. In addition to the codes cited in Section Electrical General Provisions, specific requirements for individual components of the solar system include but are not limited to the guidelines shown herein.

1.3 1.4 SUMMARY

A. Section includes:
   1. Photovoltaic (PV) modules
   2. Inverters
   3. Mounting structures (racking)

B. Description: Work includes all materials required for installation of a photovoltaic power generation system as shown on the drawings.

C. The materials in this Section are part of the overall requirements to comply with the local Energy Code.

1.4 DEFINITIONS:

A. MPPT: Maximum Power Point Tracking

B. NOCT: Normal operation cell temperature.

C. PTC: PV USA Test Conditions

D. PV: Photovoltaic

E. STC: Standard Test Conditions defined in IEC 61215
   1. Values measured at standard test conditions for PV modules (25°C cell temperature, 1000 W/m2, AM 1.5 spectrum).

1.5 REFERENCE STANDARDS:

A. NFPA 70, National Electrical Code (NEC)

B. IEEE 1262 (PV Module Qualification for Performance and Reliability).

C. IEEE 929 (Inverter Interconnection Standard).

D. Underwriters Laboratories, Inc. (UL):
1. UL 1741 Standard for Photovoltaic Inverters.
2. UL 1703 Standard for Flat-Plate Photovoltaic Modules and Panels.

1.6 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate work of this Section with work of other trades for proper time and sequence to avoid construction delays.

1.7 ACTION SUBMITTALS

A. Product Data: Submit specified products as follows:
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
2. Manufacturer's installation instructions, warranty, product data sheet.
3. Catalog pages illustrating products to be incorporated into project.

B. Shop Drawings: Indicate information on shop drawings as follows:
1. Layout and orientation of modules.
2. Layout of standoffs
3. Elevation drawings of modules and racking
4. Standoff detail
5. Detail of equipment assemblies, include dimensions, weights, loads, clearances and method of assemblies
6. Location of inverter with elevation drawings.
7. Mounting details, wind load calculations
8. Electrical connection details.
9. String, wiring, and grounding details. Electrical Line Diagram
10. Required Labeling

1.8 1.9 INFORMATION SUBMITTALS

A. Qualification Statements: The contractor installing the PV system shall have a minimum of 10 years experience and have installed at least 5 similar sized systems.
1. Submit letter of verification for Installer's Qualifications.

1.9 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
1. Submit operation and maintenance data for installed products. Include:
a. Contacts for Installation Company and manufacturer(s).
b. Manufacturer's instructions detailing maintenance requirements.
c. Operation manuals for all products used.

B. Warranty Documentation: Submit warranty documents specified.

1.10 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Having sufficient capacity to produce and deliver required materials without causing delay in work.
   2. Installer:
      a. Factory trained by the manufacturer, experienced in performing work of this section and has specialized in installation of work similar to that required for this project.
      b. Have NABCEP certified PV Installer on staff to supervise installation.

1.11 DELIVERY, STORAGE & HANDLING

A. Delivery and Acceptance Requirements:
   1. Deliver material in accordance with manufacturer's written instructions.
   2. Deliver materials in manufacturer's original packaging with identification labels intact and in sizes to suit project.

B. Storage and Handling Requirements:
   1. Store materials protected from exposure to harmful weather conditions and at temperature conditions recommended by manufacturer.

C. Packaging Waste Management:
   1. Separate waste materials for recycling.
   2. Remove packaging materials from site and dispose of at appropriate recycling facilities.

1.12 WARRANTY

A. Provide installation company warranty.

B. Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and does not limit, other rights Owner may have under other Contract Documents.
   1. Warranty Term:
      a. Freedom from Defects in Materials and Workmanship: 5 years, commencing on date of substantial completion.
      b. Percent of Minimum Power Output: 10 years, commencing on date of substantial completion.
      c. 80 Percent of Minimum Power Output: 25 years, commencing on date of substantial completion.

PART 2 - PRODUCTS

2.1 SOLAR ELECTRIC MODULES

A. Manufacturer Qualifications.
   1. Modules: Solarworld 300W, or approved alternate approved in accordance with HUD requirements. Refer to PV calculation on drawing for quantity.
   2. Single Source Responsibility: Provide components and materials specified in this section from a single manufacturer.
   3. Substitution Limitations:
      a. Substitutions: Substitutions permitted only if the equipment meets all requirements in Section 2.1.

B. Performance/Design Criteria:
   1. Complies with UL 790, Class C fire rating.
   2. Listed to UL 1703.
   3. Loading:
      a. Frames capable of withstanding loads of not less than 113 psf downwards.

2.2 ACCESSORIES

A. Mounting: Iron Ridge Racking. Installed as recommended by the manufacturer.

B. S5 Clamps for metal standing seam roof. Coordination with roofing contractor required for appropriate S5 Clamp.

C. Modules to be located on roof as shown in drawing, alternate layout acceptable if complies with Section 263100 and is coordinated with the design team.

2.3 INVERTERS

A. Manufacturer Qualifications.
   1. Inverters: comply with UL listed and NEC code requirement.
   2. System includes PV subpanel, DC disconnect, production meter, AC disconnect and connection to back fed panel
   3. Single Source Responsibility: Provide components and materials specified in this section from a single manufacturer.
   4. Substitution Limitations:
      a. Substitutions: Substitutions permitted only if the equipment meets all requirements in Section 2.3.

2.4 DESCRIPTION:

A. General
   1. The PV system for this project must comply with ASCE 7-10 wind loading standards.
   2. Modules shall be installed flush to roof surface

B. Performance/Design Criteria:
   1. Complies with IEEE 1547.
   2. Listed to UL 1703.
   3. Rated NEMA 3R.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Verify that conditions of substrates previously installed under other sections or contracts are acceptable for product installation in accordance with manufacturer's instructions prior to solar electric module installation.
   1. Inform General Contractor of unacceptable conditions immediately upon discovery.
   2. Proceed with installation only after unacceptable conditions have been remedied.

3.2 INSTALLATION

A. Coordinate installation of components in accordance with manufacturer's installation instructions.

B. Coordinate solar electric module work with work of other trades for proper time and sequence to avoid construction delays.
   1. Coordinate S5 clamps with roofing contractor

2. Coordinate OCP and conduit run with electrical contractor

C. Accurately fit, align, securely fasten and install free from distortion or defects.

3.3 SYSTEM STARTUP

A. List actions applicable to operational systems and equipment startup.
1. Commission the system to ensure that it complies with applicable code requirements and manufacturer's requirements.
2. Provide commissioning report and checklist

3.4 CLEANING

A. Upon completion, remove surplus materials, rubbish, tools and equipment.

B. Waste Management:
1. Coordinate recycling of waste materials.
2. Collect recyclable waste and dispose of or recycle field generated construction waste created during construction.

3.5 PROTECTION

A. Protect installed product from damage during installation.

B. Repair damage to adjacent materials caused by solar electric module installation.

3.6 CLOSEOUT ACTIVITIES

A. Demonstration:
1. Coordinate requirements for solar electric module demonstration.

B. Training: Coordinate training.
1. Instruct General Contractor, Owner's Rep, and/or Owner designated maintenance personnel in care, adjustment and operation of solar electric module system.
2. Provide competent instructor for not less than [1] [one-hour] training session after completion and acceptance of work.
3. Provide O&M manual, [2] paper copies and [1] digital

3.7 MAINTENANCE

A. Coordinate maintenance requirements with facility maintenance procedures

END OF SECTION 263100

SECTION 264313

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:
1. Section 262413 "Switchboards" for factory-installed SPDs.
2. Section 262416 "Panelboards" for factory-installed SPDs.

1.2 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

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

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Siemens Industry, Inc., Energy Management Division.
3. Square D; by Schneider Electric.

B. SPDs: Comply 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 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
e. Surge counter.

C. Comply with UL 1283.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 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 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V 1000 V for 208Y/120 V.

F. SCCR: Equal or exceed 100 kA.

G. Inominal Rating: 20 kA.

2.3 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Siemens Industry, Inc., Energy Management Division.
3. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 2.
1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.

C. 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.

D. Comply with UL 1283.

E. 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. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

F. SCCR: Equal or exceed 100 kA.

G. Inominal Rating: 20 kA.

2.4 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with 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, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:
1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
   1. Compare equipment nameplate data for compliance with Drawings and Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 265119

LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of LED luminaires:
1. Cylinder.
2. Downlight.
3. Highbay, linear.
4. Highbay, nonlinear.
5. Linear industrial.
6. Lowbay.
7. Parking garage.
8. Recessed, linear.
9. Strip light.
10. Surface mount, linear.
11. Surface mount, nonlinear.
12. Suspended, linear.
13. Suspended, nonlinear.

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 "Modular Dimming Controls" for architectural dimming systems and for fluorescent dimming controls with dimming ballasts specified in interior lighting Sections.
4. Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
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 IES LM-79 and IES LM-80.
   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. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

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. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which 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. Seismic Qualification Data: 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.

C. Product Certificates: For each type of luminaire.

D. Product Test Reports: For each type of luminaire, for tests performed by a qualified testing agency.

1.5 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.

1.6 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. 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 100 of each type and rating installed. Furnish at least one of each type.
   3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

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 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.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 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."

C. Ambient Temperature: 41 to 104 deg F (5 to 40 deg C).
   1. Relative Humidity: Zero to 95 percent.

D. Altitude: Sea level to 1000 feet (300 m).

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. 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.

C. Recessed luminaires shall comply with NEMA LE 4.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. California Title 24 compliant.

2.3 CYLINDER.

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
   1. Minimum 575 lm.
   2. Minimum allowable efficacy of 80 lm/W.
   3. CRI of minimum 80. CCT of 3000 K.
   4. Rated lamp life of 50,000 hours to L70.
   5. Dimmable from 100 percent to 0 percent of maximum light output.
   6. Internal driver.
   7. User-Replaceable Lamps:
      a. Bulb shape complying with ANSI C78.79.
      b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
   8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
   1. Extruded-aluminumhousing and heat sink.
   2. Clear anodized finish.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
   1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. With integral mounting provisions.

H. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.4 DOWNLIGHT.

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 575 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

E. 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.

F. Diffusers and Globes:
1. Fixed lens.
2. Medium light distribution.
3. Diffuse glass.
4. 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.
5. Glass: Annealed crystal glass unless otherwise indicated.
6. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. Recessed luminaires shall comply with NEMA LE 4.

2.5 LINEAR INDUSTRIAL.

A. Refer to lighting fixture schedule for Manufacturer

B. Lamp:
1. Minimum 5,000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.

D. Housing and Heat Sink Rating:

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. With integral mounting provisions.

H. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.

2.6 PARKING GARAGE.

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 2,000 lm.
2. Minimum allowable efficacy of 75 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. Low-profile housing and heat sink.
4. Fully gasketed and sealed. IP 65 rated.
5. Stainless-steel latches.
6. Integral pressure equalizer.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. With integral mounting provisions.

H. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.7 RECESSED, LINEAR.

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 1,500 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. NEMA LE 4.

2.8 STRIP LIGHT.

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 750 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of 80 Insert number. CCT of 3000 K Insert value.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
a. Bulb shape complying with ANSI C78.79.
b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear Insert color anodized finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping of luminaire without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.9 SURFACE MOUNT, LINEAR.

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 750 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.10 SURFACE MOUNT, NONLINEAR

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 750 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.11 SUSPENDED, LINEAR

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 1,500 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.12 SUSPENDED, NONLINEAR

A. Refer to lighting fixture schedule for Manufacturer

B. Nominal Operating Voltage: 120 V ac.

C. Lamp:
1. Minimum 1,500 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. CRI of minimum 80. CCT of 3000 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1.
8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:
1. Diffuse 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 (3.175-mm) minimum unless otherwise indicated.

G. Standards:
1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.13 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. Steel:
1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:
1. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.14 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.

2.15 LUMINAIRE SUPPORT

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 (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) 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 luminaire installation.

C. 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 a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:
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 Luminaires:
1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:
1. Ceiling Mount:
   a. Two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 10 feet (3 m) in length.
   b. Pendant mount with 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 10 feet (3 m) in length.
   c. Hook mount.
2. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
3. 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.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. 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.

I. 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 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.7 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 265213

EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Emergency lighting units.
   2. Exit signs.
   3. Luminaire supports.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
   1. Include data on features, accessories, and finishes.
   2. Include physical description of the unit and dimensions.
   3. Battery and charger for light units.
   4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
   5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
      a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires and signs 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 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.

C. Product Schedule:
   1. For emergency lighting units. Use same designations indicated on Drawings.
   2. For exit signs. Use same designations indicated on Drawings.

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. Luminaires.
   2. Suspended ceiling components.
   3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
   4. Structural members to which equipment will be attached.
   5. Size and location of initial access modules for acoustical tile.
   6. Items penetrating finished ceiling including the following:
      a. Other luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Ceiling-mounted projectors.
      e. Sprinklers.
      f. Access panels.
   7. Moldings.

B. Product Certificates: For each type of luminaire.

C. Seismic Qualification Data: 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.
   4. Provide seismic qualification certificate for each piece of equipment.

D. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
   3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

C. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.
   1. Obtain Architect's approval of luminaires and signs 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.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.
   1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.

2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   a.
3. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

I. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.
1. Emergency Connection: Operate one LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Battery: Sealed, maintenance-free, nickel-cadmium type.
4. Charger: Fully automatic, solid-state, constant-current type.
5. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the emergency power unit manufacturer, whichever is less.
6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Luminaires:
1. Refer to lighting fixture schedule for Manufacturer
2. Emergency Luminaires: as indicated on Drawings, with the following additional features:
   a. Operating at nominal voltage of 120 V ac.
   b. External emergency power unit.
   c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.

d. UL 94 HB flame rating.

C. Emergency Lighting Unit:
1. Refer to lighting fixture schedule for Manufacturer
2. Emergency Lighting Unit: as indicated on Drawings.
3. Operating at nominal voltage of 120 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. Two LED lamp heads.
7. Internal emergency power unit.

2.4 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:
1. Refer to lighting fixture schedule for Manufacturer
2. Operating at nominal voltage of 120 V ac.
3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
6. Master/Remote Sign Configurations:
a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

C. Self-Luminous Signs:
1. Refer to lighting fixture schedule for Manufacturer
2. Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for 10 years.

2.5 MATERIALS

A. Metal Parts:
1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:
1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
1. Diffuse glass.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:
   1. Extruded aluminum housing.
   2. Clear anodized finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch (21 mm) in diameter.

2.6 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.7 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire and emergency power unit weight.
   2. Able to maintain luminaire position when testing emergency power unit.
   3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls.
   2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.

2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod 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.

G. Ceiling Grid Mounted Luminaires:
1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
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.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:
1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:
1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265213

SECTION 265613

LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Poles and accessories for support of luminaires.

1.2 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete luminaire.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.3 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.
1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.

B. Shop Drawings:
1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of poles and pole accessories.
4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
6. Method and procedure of pole installation. Include manufacturer's written installations.

1.4 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Seismic Qualification Data: For 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. Material Test Reports:
1. For each foundation component, by a qualified testing agency.
2. For each pole, by a qualified testing agency.

D. Field quality-control reports.

E. Sample Warranty: Manufacturer's standard warranty.

F. Soil test reports

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C1093 for foundation testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B660.

B. Store poles on decay-resistant skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.
1. Warranty Period: Five years from date of Substantial Completion.
2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the system 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. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.
   1. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 90 mph (40 m/s).
      a. Wind Importance Factor: 1.0.
      b. Minimum Design Life: 25 years.
      c. Velocity Conversion Factor: 1.0.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American LitePole.
   2. Cooper Lighting, an Eaton business.
   3. KIM Lighting.
   4. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

C. Poles: Comply with ASTM A500/A500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
   1. Shape: Round, straight.
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

D. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

E. Brackets for Luminaires: Detachable, cantilever, without underbrace.
   1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with galvanized-steel bolts.
   2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

F. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

G. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
   1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

H. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

I. Steps: Fixed steel, with nonslip treads.
   1. For climbing positions, install at 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole, oriented 180 degrees from each other; first step shall be at an elevation 10 feet (3 m) above finished grade.
   2. For working positions, install steps on opposite side of pole, oriented 180 degrees from each other at the same elevation.

J. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

K. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch (76-by-130-mm) handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

L. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

M. Platform for Lamp and Ballast Servicing: Factory fabricated of steel, with finish matching that of pole.

N. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

O. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A123/A123M.

P. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces according to 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, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
   3. 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 indicated by manufacturer's designations.

Q. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Powder Coat: Comply with AAMA 2604.
      a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils dry film thickness. Coat interior and exterior of pole for equal corrosion protection.
      b. Color: As selected by Architect from manufacturer's full range.

2.3 ALUMINUM POLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American LitePole.
   2. Cooper Lighting, an Eaton business.
   3. KIM Lighting.
   4. Lithonia Lighting; Acuity Brands Lighting, Inc.

B. Poles: Seamed, extruded structural tube complying with ASTM B221, Alloy 6063-T6, with access handhole in pole wall.

C. Poles: Seamed, extruded structural tube complying with ASTM B221, Alloy 6061-T6, with access handhole in in pole wall.
   1. Shape: Round, straight.
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

D. Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

E. Brackets for Luminaires: Detachable, cantilever, without underbrace.
   1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with galvanized-steel bolts.
   2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

F. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

G. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

H. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
   1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

I. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

K. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" 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 of 0.018 mm or thicker), complying with AAMA 611.
   4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; 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.

L. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" 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, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
   3. 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 by Architect from manufacturer's full range.

M. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" 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 powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Powder coat shall comply with AAMA 2604.
      a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5- mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.
      b. Color: As selected by Architect from manufacturer's full range.

2.4 WOOD POLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Pole & Timber.
   2. Stella-Jones.
   3. TimberWood Products; J.H. Baxter & Co.
   4. United Wood Treating Company.

B. Poles: Douglas fir, for wood species used; and bored, roofed, and grained before treatment.
   1. Pole Brand: Brand the manufacturer's trademark and date of treatment, height and class of pole, wood species, preservation code, and retention. Brand shall be placed so that the bottom of the brand is minimum 10 feet (3 m) from pole butt.
   2. Mounting Provisions: Embedded.

C. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
   1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

D. Preservative Treatment: Treat according to AWPA UC4A.

E. Luminaire Brackets: Comply with ANSI C136.13.

2.5 POLE ACCESSORIES

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 262726 "Wiring Devices."
   1. Surface mounted 12 inches (300 mm) above finished grade.
      a. NEMA 250, Type 3R, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.
      b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

D. Transformer-Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and to accept indicated accessories. Include removable flanged access cover secured with bolts or screws.

2.6 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi (380,000 kPa).
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
2. Bent rods Insert inches (mm) in diameter by in length.
3. Threading: Uniform National Coarse, Class 2A.

B. Nuts: ASTM A563, Grade A, Heavy-Hex
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
2. Four nuts provided per anchor bolt.

C. Washers: ASTM F436, Type 1.
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
2. Two washers provided per anchor bolt.

2.7 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: 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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.2 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.
   1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than one-sixth of pole height. Add backfill in 6-inch (150-mm) to 9-inch (230-mm) layers, tamping each layer before adding the next. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.
   1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
   2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days and finish in a dome above finished grade.
   3. Use a short piece of 1/2-inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
   4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: Install plumb using manufacturer-supplied steel template, uniformly spaced.

3.3 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.
   1. Fire Hydrants and Water Piping: 60 inches (1520 mm).
   2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet (3 m).
   3. Trees: 15 feet (5 m) from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.
   1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   3. Install base covers unless otherwise indicated.
   4. Use a short piece of 1/2 -inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-(150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Inspect poles for nicks, mars, dents, scratches, and other damage.
   2. System function tests.

END OF SECTION 265613

SECTION 265619

LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
   2. Luminaire supports.
   3. Luminaire-mounted photoelectric relays.

B. Related Requirements:
   1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Section 260933 "Central Dimming Controls" or Section 260936 "Modular Dimming Controls" for architectural dimming systems specified in Section 265100.
   3. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.
   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 LM-80.
      a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
   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. Product Schedule: For luminaires and lamps.

D. Delegated-Design Submittal: For luminaire supports.
1. Include design calculations for luminaire supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, 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 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. Seismic Qualification Data: 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.

C. Product Certificates: For each type of the following:
1. Luminaire.
2. Photoelectric relay.

D. Product Test Reports: For each luminaire, for tests performed by a qualified testing agency.

E. Source quality-control reports.

F. Sample warranty.

1.5 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.

1.6 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. 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 100of 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.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

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.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.9 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.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
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: 2 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 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 120 V ac.

L. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

M. Source Limitations: Obtain luminaires from single source from a single manufacturer.

N. 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-MOUNTED PHOTOELECTRIC RELAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Lighting, an Eaton business.
   2. Deco Lighting.
   3. Lithonia Lighting; Acuity Brands Lighting, Inc.
   4. Philips Lighting Company.

B. Comply with UL 773 or UL 773A.

C. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
   1. Relay with locking-type receptacle shall comply with ANSI C136.10.
   2. Adjustable window slide for adjusting on-off set points.

2.4 LUMINAIRE TYPES

A. Area and Site:
   1. Refer to lighting fixture schedule for Manufacturer

B. Bollard:
   1. Refer to lighting fixture schedule for Manufacturer

C. Border:
   1. Refer to lighting fixture schedule for Manufacturer

D. Canopy:
   1. Refer to lighting fixture schedule for Manufacturer

E. Decorative Post Top:
   1. Refer to lighting fixture schedule for Manufacturer

2.5 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Stainless steel. 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. Glass: Annealed crystal glass unless otherwise indicated.
   2. Lens Thickness: At least 0.125 inch (3.175 mm) 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.

2.6 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: Refer to lighting fixture schedule for Manufacturer

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 by Architect from manufacturer's full range.

2.7 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 structural members in walls.

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 Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:
1. Install on concrete base with top 4 inches (100 mm) 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 (100 mm) 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- (0.254-mm-) 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:
   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. 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 00 00

GENERAL PROVISIONS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Description of Work: Provide materials, labor, supervision, tools, equipment and machinery and other services necessary to complete the work to provide a complete, fully functional and operational cable plant infrastructure as described herein and as shown on the drawings.

B. Related Work Specified Elsewhere: The provisions and intent of the General Conditions, Special Conditions and General Requirements apply to the work as if specified in this section and other sections of Specifications and Drawings of the Contract Documents.

C. Mounting details of equipment, racks, cabinets, cable tray, ladder rack, outlets, devices and the like are usually shown or specified. Where not shown or specified, provide per standard industry practice, referenced standards, or code requirements as necessary for proper installation and operation the same as if herein specified or shown.

D. Where items of the General Conditions or of the Special Conditions are repeated in this Section or other sections of the Specifications, it is intended to call particular attention or to qualify them; it is not intended that any other parts of the General Conditions or Special Conditions shall be assumed to be omitted if not repeated herein.

E. Non-specified Work: Where materials or equipment are indicated, they are intended to be provided complete and shall include all accessories, hardware, supports and appurtenances to provide a complete and fully functioning system. All such accessories, hardware, supports and appurtenances shall be provided unless specifically excluded or indicated to be provided by others.

1.2 PERMITS AND FEES

A. Purchase all fees, permits, licenses and approvals required for execution of work.

B. Contractor is responsible for coordination and scheduling of inspections, and for obtaining approvals of work by the authority having jurisdiction of that work.

1.3 CODES AND STANDARDS

A. All communication work shall be executed in strict accordance with the latest edition of the National Electrical Code and governing state and local ordinances, codes and regulations.

B. Assure the strict conformity of telecommunication and communication equipment, materials, construction methods, testing, labeling and definitions with the latest adopted revision of the referenced Standards.

C. Specifications and drawings shall govern in those instances where requirements are greater than those specified in the referenced standards.

D. Contractor shall be familiar with all codes and standards applicable to their work. Where two or more codes or standards are in conflict, that requiring the highest order of workmanship shall take precedence.

E. Contractor shall notify the Designer and Everett Housing Authority of any discrepancies between the design and applicable code requirements so that any conflicts can be resolved.

F. Nothing in this document shall be deemed to authorize or direct Contractor to deviate from telecommunications industry standards, federal, state, or local safety laws standard, code or requirement.

1.4 RELATED SECTIONS

A. Section 27 05 26 – Grounding and Bonding for Communications Systems

B. Section 27 13 23 – Communications Optical Fiber Backbone Cabling

C. Section 27 15 13 – Communications Copper Horizontal Cabling

1.5 REFERENCES

A. The latest published release or version of the publications listed below form a part of this specification to the extent referenced:

1. ANANSI/EIA/TIA Standards

ANSI/TIA-568-C.0	Generic Telecommunications Cabling for Customer Premises (August 2012)
ANSI/TIA-568-C.1	Commercial Building Telecommunications Cabling Standard – (May 2012)
ANSI/TIA-568-C.2	Balanced Twisted-Pair Telecommunications Cabling and Components Standards (November 2014)
ANSI/TIA-568-C.3	Optical Fiber Cabling Components Standard (December 2011)
ANSI/TIA-568-C.4	Broadband Coaxial Cabling and Components Standard (July 2011)
ANSI/TIA/EIA-569-C	Commercial Building Standards for Telecommunications Pathways and Spaces (May 2012)
ANSI/TIA/EIA-604.2-B,	FOCIS 2 Fiber Optic Connector Intermateability Standard, (August 2004)
ANSI/TIA/EIA-606-B	Administration Standard for Telecommunications Infrastructure (June 2012)
ANSI/TIA/EIA-854, A	Full Duplex Ethernet Specification for 1000 Mb/s (1000BASE-TX) Operating over Category 6 Balanced Twisted-Pair Cabling, 2001
J-STD-607-A	Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications (October 2002)
TIA TSB-140	Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems (April 2004)
TIA/EIA TSB-125	Guidelines for Maintaining Optical Fiber Polarity Through Reverse-Pair Positioning, (June 2001)
TIA/EIA-862-A	Building Automation Systems Cabling for Commercial Buildings, (April 2011)
TIA-526-14-B	Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 Edition 2, Fiber-Optic Communications Subsystem Test Procedure - Part 4-1: Installed

	Cable-Plant Multimode Attenuation Measurement (October 2010)
TIA-526-7	OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant (December 2008)
TIA-758-B	Customer-Owned Outside Plant Telecommunications Infrastructure Standard (April 2012)
TIA-942-A	Telecommunications Infrastructure Standard for Data Centers, (August 2012)
TSB-155-A	Guidelines for the Assessment and Mitigation of Installed Category 6 Cabling to Support 10GBASE-T, (March 2010)
ANSI X3T9.5	Requirements for UTP at 100 Mbps
ANSI/NECA/BICSI-586-2006	Standard for Installing Commercial Building Telecommunications Cabling
ANSI/NECA/BICSI-568-2006	BICSI Outside Plant Design Reference Manual (COOSP), 4th edition

2. BISCI Standards

BICSI ESSDRM	BICSI Electronic Safety and Security Reference Manual 2nd edition
BICSI ITSIM	BICSI Information Transport Systems Installation Methods Manual, 5th edition
BICSI NDRM	BICSI Network Design Reference Manual, 6th edition
BICSI TDMM	BICSI Telecommunications Distribution Methods Manual, 13th edition
BICSI WDRM	BICSI Wireless Design Reference Manual, 3rd edition

3. Other US Standards

IEEE	Institute of Electrical and Electronic Engineers
IBC	International Building Code
NFPA 70	National Electrical Code
UL	Underwriters Laboratory
NEMA	National Electrical Manufacturers Association
UL	Underwriters Laboratories Cable Certification and Follow Up Program

B. The above standards shall be incorporated by reference to each other Division 27 supplementary telecommunication specification section to the full extent applicable.

1.6 CONTRACT DOCUMENTS

A. These Specifications and Drawings are intended to describe a completed installation for one or more communication systems as described herein. Any omission of expressed reference to any item of labor or material required for a proper execution of the work in accordance with the present industry or trade practice shall not relieve the Contractor from providing such labor and material. Refer to the Drawings, Shop Drawings or other trades for additional details which may affect the proper installation of this work.

1.7 DEFINITIONS

A. The term “approved equal” shall mean final approval by the Designer of a material or piece of equipment substituted for that which is shown in the Specifications or on the Drawings.

B. The word “provide” used in the Specifications and on the Drawings shall mean “furnish and install, complete and ready for intended use”.

C. The word “furnish” as used in the Specifications and on the Drawings shall mean “to supply and deliver to project site, ready for installation”.

D. The word “install” used in the Specifications and on the Drawings shall mean “to place in position, and to connect complete per factory instructions, ready for service or use.”

E. The word “Designer” shall mean the professional person or firm responsible for the system design; and the development and preparation of these Specifications and Drawings.

F. The term “Owner’s Representative” shall mean the person designated to administer the terms and conditions of the Plans and Specifications after the contract award and during the construction or installation phase.

G. The term “electronic copy” used in the Specifications and on the Drawings shall mean a copy of a document or set of documents in an electronic format. Such document and/or copy, unless noted otherwise, shall be prepared with specific application software as follows:
1. as related to Drawings, a copy in the latest release of Revit and AutoCAD and Adobe pdf.
2. as related to word documents, a copy in the latest version of Everett Housing Authority Word;
3. as related to spreadsheets, a copy in the latest version of Everett Housing Authority Excel;
4. as related to pictures or photos, in .jpg or .jpeg format,
5. as relating to all other documents, a copy of the document in the latest version of the software application used by the Designer to create the original document.

1.8 CONTRACTOR QUALIFICATIONS

A. Contractors performing on-site communication work specified in this Division shall conform to the qualification conditions set forth in this Section.

B. Contractor shall:
1. have maintained a continuously established place of business within 25 miles of the project site for the previous five (5) years prior to start of work and agrees to conduct all business for this project from the local office.
2. demonstrate experience in the installation of the specified system continuously for the five (5) years immediately prior to bid date.
3. have full time technicians on staff assigned to this project who are trained, skilled, experienced and regularly employed in the communication trade involved.
4. utilize direct employees for all office and field work for this project and maintain sufficient direct staff during the project duration to perform all project functions.
5. have at the time of bid an available staff and labor force to perform all work for this project and shall not subcontract, outsource or otherwise indirectly employ any office or field staff worker throughout the term of this project. All workers and staff shall be full-time, permanent employees.
6. possess in-house staff, software and hardware, including plotter to provide electronically drafting capabilities using Revit 2012 and AutoCAD 2013.

C. Contractor shall have at least (1) BICSI Registered Communications Distribution Designer (RCDD) on staff as a permanent, full-time employee.

D. Each technician assigned to this project:
1. shall be trained in category-rated copper and optical fiber installation techniques by BICSI.
2. terminating and testing copper or optical fiber shall have at least (3) years’ experience in the termination and testing of the associated cable.
3. performing terminations shall be in possession of a manufacturer-issued certificate certifying that the technician has received factory-approved training in the specific cable and termination

products being used. Training and certificate shall not be older than (2) years from the date the cable is terminated.

4. performing testing of copper and optical fiber cabling shall be in possession of a manufacturer-issued training certificate for the specific tester(s) being employed. Training and certificate shall not be older than (2) years from the date the cable test is performed.

E. All certifications shall be “standing” certifications. ” Project-only”, “project-specific” or temporary certifications are not acceptable.

F. In addition to the documentation required in the “BID SUBMISSIONS” paragraph of this Section, Everett Housing Authority shall be able to further evaluate the Contractor’s qualifications and abilities though visits and inspections of the local office and/or previous project installations and/or oral or written interviews.

1.9 BID SUBMISSIONS

A. All bidders for Communications work for this project shall include with their bid response written verification they are able meet the qualification requirements of this Section and they have ready and available a labor force sufficient to perform the work herein within the construction schedule timeline.

B. Contractor qualification documentation shall include:
1. a list of recently completed projects of similar type and size with contact names and telephone numbers for each.
2. a list of test equipment proposed for use in verifying the installed integrity of copper and optical fiber cable systems on this project. Each item of test equipment shall include the last date of calibration, calibration report and name and company of person performing the calibration.
3. re-certification plan of test equipment where calibration will expire prior to test date will be re-calibrated
4. a resume of qualifications and experience for the contractor's Project Manager and on-site installation supervisors, and for technicians who will be assigned to this project.
5. Resumes shall include training certificates, including training hours, received as a result of training classes conducted by a factory-authorized representative for communication products specified within this Division.
6. a list of their support staff, together with their training qualifications, in the same manner as prescribed above.
7. the resumes and company profiles of any subcontractors the bidder proposes to use on this project or manufacturing process. Subcontractors shall possess the same training and product certifications as the Contractors.
8. a letter of approval from the manufacturer(s) indicating completion of pre- qualification requirements and ability of Contractor to provide extended manufacturers warranties.
9. training certificates for design, engineering and installation of the proposed products, for the relevant staff involved in the design and installation of this project

C. Bidder shall submit with Bid a fully completed Bill of Materials form. This form shall be in the format proscribed by Everett Housing Authority and shall include each and every product indicated on the Drawings or in these Specifications with the exact quantity, length or size required for Everett Housing Authority to place a single procurement order for communications materials for this project.

1.10 SUBSTITUTIONS

A. The naming of a certain manufacturer or product in the Specifications is to establish a standard of quality for the article desired. However, Everett Housing Authority always encourages all parties throughout the process to present better and lower-cost methods to achieve our goals. This will be usually limited to different products within our preferred manufacturer offerings and to products not included in our preferred buying stream.

B. The Contractor is restricted to the use of the specific brand of manufacturer named unless so indicated in the Specification or notified during bidding. A substitution request is required for any product other than the one specified, and the furnishing and installing of such substitute product is permitted only with written approval of the Designer. No substitute material or equipment shall be ordered, fabricated, shipped, procured or processed in any manner prior to the written approval of Everett Housing Authority.

C. The Contractor must submit sufficient information to show that a proposed substitute is equivalent to the item specified. Acceptance of substitutions is at the Designer's or Everett Housing Authority's discretion: The Designer and Everett Housing Authority reserve the right to determine suitability of the substitute product and reject any and all materials submitted for substitution. Products rejected or otherwise judged unsatisfactory by Everett Housing Authority will not be authorized for use in completing the Work.

D. The Contractor shall assume responsibility of and for any additional expenses required to meet changes from the original material or equipment specified.

1.11 SUBMITTALS

A. Data Sheets: Each of the submitted copies must be provided in a standard size, 3-ring binder in an organized manner. Partial submittals will be rejected unless otherwise noted. Data sheets or catalog cuts of all electronic and other equipment, cable, connectors, faceplates, raceways, equipment racks and cabinets, patch panels, wiring blocks, faceplates, assemblies and basic materials must be included. For all substituted materials not approved, the Contractor shall provide the material item as specified. Copies showing approvals, any changes or comments will be returned to the Contractor.

B. Additionally, where specified or requested, provide submittals in electronic format. Deliver to Owner's Representative in the manner requested such as email or posting to e- doc website.

C. Drawings: Where specified in other sections of this Specification, submit detailed installation drawings of equipment and wiring. Drawings shall indicate only the information applicable to the specific specification section. Drawings shall be of the same size and scale and prepared in a neat, legible and professional format similar to the Contract Documents.

1.12 CHANGE ORDERS

A. Promptly report requests for additional materials or work in writing and maintain written records of additions (change order request) separate from the original project.

B. Changes to contractor's project scope, system routing, schedule or authorized budget must be approved in advance by the Owner. Contractor will not be paid for any work performed, or materials purchased without advance authorization and approval for the specific items of work or materials by the Owner.

1.13 SAFETY

A. Contractor is responsible to provide and maintain necessary safety devices, barriers, components, and supervision associated with this work and to protect the safety of pedestrians, facility occupants, bystanders, and Contractor's employees.

B. Conform to safety standards specified in Division 01.

1.14 QUALITY ASSURANCE AND WORKMANSHIP

A. All work shall be performed in a neat, workmanlike manner in keeping with the highest standards of the craft and in harmony with other trades to provide a neat and finished appearance. Only good workmanship will be accepted. If, in the opinion of the Owner's Representative, work is not installed

in a workmanlike manner, or leaves a rough, unfinished appearance, such work shall be completely removed, replaced correctly in its entirety, and all surrounding surfaces patched and painted at no additional cost to the Owner.

B. All work shall be performed in accordance with the Specifications, Drawings, referenced standards, and all applicable national and local codes and regulations.

C. Everett Housing Authority's requirements for design compliance, documentation, labeling, neatness, economy and cooperation with other contractors exceed generally accepted practices. Contractor shall comply with this high level of workmanship and coordinate with the Owner or their representatives to achieve these objectives.

D. Everett Housing Authority shall be the sole arbitrator whether the level of workmanship meets these specification conditions. Contractor shall fully understand the level of effort required prior to start of work.

E. Methods of construction that are not specifically described or indicated in these Specifications or on the drawings shall be subject to the control and approval of Everett Housing Authority.

1.15 SCHEDULING, EQUIPMENT AND STORAGE

A. Schedule materials and equipment and other deliveries and make all arrangements as necessary to complete all work in accordance with the project construction schedules. Provide schedules of work to Owner's Representative as directed during construction.

B. Schedule deliveries and unloading to prevent traffic congestion, blocking of access, and interference with work. Arrange deliveries to avoid larger accumulations that can be suitably stored at site. Provide all labor and equipment to rig, hoist, lower and move materials and equipment on and around site, within the building or on the roof.

C. Contractor shall be present to accept all material deliveries related to this scope of work and shall sign for all deliveries. Produce and maintain a log of received materials in both hard and electronic format containing at a minimum:
   1. A description and quantity of received item(s);
   2. The date of receipt;
   3. The location the item was received;
   4. The location where the item is stored;

D. Receive packaged materials at site in manufacturer's original, unopened, labeled containers. Do not open containers until approximate time for use.

E. Provide lockable storage containers, or other Owner-approved secured storage methods, for all on-site secure storage of materials. Store materials at locations that will not interfere with progress of work. Arrange locations of storage areas and containers in approximate order of intended use.

F. Store materials in a manner that will prevent damage to materials and structure. Store cementitious materials in dry, weather tight, ventilated spaces. Store ferrous materials to prevent contact with ground and to avoid rusting and damage from weather. Store electronic and performance-dependent items and materials according to manufacturer directions, and in environment no more extreme than the final permanent environment such equipment or materials will operate within.

G. Provide documents to Owner's Representative for any claim of material or equipment deliveries not able to meet construction schedules.

1.16 SITE EXAMINATION

A. Before submitting bid, Contractor shall visit the site and examine all work and operational areas, communication services, equipment and space conditions on which the work is in any way dependent

so as to provide the best workmanship and operation according to the intent of the Specifications and Drawings. Report to the Owner's Representative any condition that might prevent the installation of the material and performance of work in the manner intended.

1.17 PRE-CONSTRUCTION CONFERENCE

A. Attend a pre-construction conference with the A/E, Owner, and related contractors for coordination of with work specified in this Section a minimum of 15 calendar days before start of work.

1.18 WARRANTY

A. Contractor shall warranty all parts and labor for a period of one year, commencing on the date of substantial completion of the work.

B. Where indicated elsewhere in the Specification, Contractor will provide an additional extended warranty to the customer. The Contractor shall register the system and associated products with the manufacturer and ensure customer receives all warranty documents and instructions. Proof of the Contractor's ability to provide this warranty shall be provided as part of the bid process.

C. Each warranty will provide remedy of any defects of workmanship and repair or replace any faulty components that fail during the warranty period, without additional cost to the owner.

D. Provide (2) copies of a warranty binder containing:
   1. Warranty information for components and Contractor's labor.
   2. Signed and dated warranty documentation from the manufacturer for extended component warranties.
   3. Copies of a letter, on contractor firm's letterhead, signed and dated by a corporate officer or the regional manager, and additionally signed by the project manager. The letter shall state that the materials utilized are as specified in the contract, that installation complies with applicable manufacturers' specifications and telecommunications industry standards, and that the contractor performed required cable and link tests. Include statement that every cable and cable pair for copper and every strand for fiber has been tested.

E. Provide a warranty on labor such that any installation or documentation found within one

F. (1) year to be out of compliance with these specifications will be promptly repaired or replaced at no charge.

G. Provide in warranty binder extended (15-30 year cabling and hardware manufacturer warranties) manufacturer warranties provided by this Project. Projects shall contain products eligible for extended manufacturer warranties.

H. Warranty service shall be available 24 hours/day; 7 days/week. Emergency response shall be within two hours of notification. The classification of "emergency" shall be defined solely by the Owner. Longer response times are at the sole discretion of the Owner. If the contractor does not respond within two hours, or within the longer time prescribed by the Owner, the Owner may contract with others and the cable contractor shall reimburse the Owner its actual cost as a remedy.

I. Scope of warranty includes equipment, devices, wiring, accessories, software, hardware, installation, programming, and configuration required to maintain a complete and operable system. Provide manufacturer's published recommended preventative maintenance procedures during warranty period. This shall apply to items except those specifically excluded, or items wherein a longer period of service and warranty is specified or indicated. Warranties shall be effective for one year, minimum, from date Certificate of Final Acceptance is issued. Use of systems provided under this section for temporary services and facilities shall not constitute final acceptance of work nor beneficial use by Owner and shall not institute warranty period. The warranty shall cover repair or replacement of defective materials, equipment, workmanship, and installation that may be incurred during this period. Warranty work is to be done promptly and to Owner's satisfaction. In addition, warranty shall

cover correction of damage caused in making necessary repairs and replacements under warranty. Additional warranty responsibilities are:

1. Obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's designated name.
2. Replace material and equipment that require excessive service during guarantee period as determined by Owner.
3. Provide 2-business day service beginning on date of Substantial Completion and lasting until termination of warranty period. Service shall be at no cost to Owner. Service can be provided by installing contractor or by a separate service organization. Choice of service organization shall be subject to Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of week, for duration of service.
4. Submit copies of equipment and material warranties to Owner before final acceptance.
5. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to Owner.
6. If warranty work problems cannot be corrected immediately to Owner's satisfaction, advise Owner in writing, describing efforts to correct situation, and provide analysis of cause for problem. If necessary, to resolve problem, provide at no cost services of manufacturer's engineering and technical staff at site in a timely manner to analyze warranty issues, and develop recommendations for correction, for review and approval by Owner.

J. Structured Cabling System (SCS) Manufacturers Extended Warranty:
   1. SCS Systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified vendor. Manufacturer shall administer a follow on program through the Vendor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support the applications for which it is designed, during the 20-year warrantee of the certified system.
   2. The second portion of the certification is a 20-year warranty provided by the manufacturer and the vendor on products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).
   3. In the event that the certified system ceases to support the certified application(s), whether at the time of cutover, during normal use or when upgrading (e.g. ATM), the manufacturer and vendor shall commit to promptly implement corrective action.
   4. Documentation proving the cabling system's compliance to the End-to-End Link Performance recommendations, as listed in ANSITIA/EIA-568-C shall be provided by the Vendor prior to the structured cabling system being installed.
   5. The cabling system must conform to the most current issue of industry standard ANSI/TIA/EIA-568. Performance requirements of this document must be followed. As well, workmanship and installation methods used shall be equal to or better than that found in the BICSI (Building Industry Consulting Service International) ITSI manual.
   6. Purchaser demands strict adherence to the performance specifications listed in ANSI/TIA/EIA-568-B series standards.
   7. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacturer the product used in this cabling system.

K. Owner's rights: This section shall not be interpreted to limit Owner's rights under applicable codes and under this Contract.

L. Pathways Material and Installation Warranty: Provide services, materials and equipment necessary to warrant the installation and performance of pathway materials for a period of one year after beneficial use. Scope of warranty includes equipment, devices, installation and other work required to maintain a complete and operable system. Provide manufacturers published recommended preventative maintenance procedures during warranty period.

M. Grounding and Bonding Material and Installation Warranty: Provide services, materials and equipment necessary for successful operation of GBS for a period of one year after beneficial use. Scope of warranty includes equipment, devices, installation and other work required to maintain a

complete and operable system. Provide manufacturers published recommended preventative maintenance procedures during warranty period.

N. Firestopping Material and Installation Warranty: Provide services, materials and equipment necessary to warrant the performance of Firestopping material for a period of one year after beneficial use, or longer if required by the local AHJ. Scope of warranty includes equipment, devices, installation and other work required to maintain a complete and operable system. Provide manufacturers published recommended preventative maintenance procedures during warranty period.

1.19 RECORD DOCUMENTS

A. As-Built Drawings: Contractor shall maintain a set of Contract Plans at the project site on which current changes and the actual location of pathways, including underground and overhead conduits and cable trays, outlets, racks, connection hardware, outlets, etc. as-installed, shall be marked in red pencil in a neat, legible manner. This set of plans shall show actual dimensions from construction lines so they may be readily found after covering. Plans shall include all rack, pathway, patch panel, wiring block, outlet and cable numbering/labeling and any other changes from the Contract Documents. Any ductbanks, vaults and handholes shall indicate exact GPS coordinates with ductbanks or buried conduits identified at 50 foot minimums and at all turns.

B. Within fifteen (15) days of completion of the project, Contractor shall transmit the As- Built drawings to the AE. The contractor shall produce an electronic set of drawings reproduced from marked-up As-Builts and deliver two (2) bound full-size hard copies, two (2) bound half-sized hard copies and (2) electronic copies in CD format to the Owner's Representative for approval.

C. Record Documents: The following documents shall be presented to the Owner's Representative prior to final acceptance of the project. Bind three (3) complete sets of the following in a hard-backed three-ring binder:
1. Signed letter from the Contractor stating their system portion of the project is complete and that all punch list items are completed;
2. Signed letter from the Contractor stating that all materials used are as specified, that each component of the installation complies with all manufacturers' instructions and telecommunications industry standards, and that the contractor has performed all specified testing and/or commissioning;
3. Inspection Certificate, where applicable;
4. Copies of all permits, where applicable;
5. Log of all Everett Housing Authority-requested changes;
6. Log of all RFIs (Requests for Information) and ASIs (Architectural Supplemental Instructions) with the actual RFI and ASI documents;
7. Copies of all communication change orders with a summary of changes;
8. Operating and Maintenance Manuals, operating instructions;
9. Additional copies of all Warranties and Guarantees.
10. Test Results: Transmit test results in accordance with the Specifications for each system

1.20 MAINTENANCE AND OPERATIONS MANUAL

A. General: Provide one (1) preliminary bound set of Operations and Maintenance Manuals. Include parts list and all maintenance information furnished by the manufacture. Include supplementary or shop drawings where necessary to indicate points of service and maintenance. Include recommended periodic maintenance, operating instructions, and data and warranty forms from the manufacturer for each item of equipment installed. Provide address and 24-hour phone number of firm responsible under warranty. Items requiring service or correction during the warranty period shall be serviced within 24 hours of notification by Owner. Data in manuals shall be clean, neat copies and posted on typed, 8- 1/2"x11" sheets. Drawings shall be accordion folded. An index shall be provided with contents listed in an orderly presentation according to Specification section.

B. Number of Copies: The preliminary set of the O&M Manual shall be presented to the Owner's Representative for approval by the Designer. After approval of this set, indicated corrections shall be made and two (2) additional sets shall be prepared and the three (3) completed sets shall be transmitted to the Owner's Representative.

C. Binding: Copies shall be bound in a hard-backed three-ring binder. A cover sheet will be affixed to the front and contain the name of the job, Owner, Architect, Designer, Contractor and the year of completion. The spine holder shall contain a binding label containing the name of the project, Owner and year of completion. Each copy shall have a typewritten index and tabbed dividers between equipment categories.

1.21 SUPPORT SERVICES

A. Maintenance: Beginning at acceptance by the Owner, provide a separate optional annual price for years one, two, three, four and five for 12 months' full maintenance by skilled employees of the Contractor's or manufacturer's own service organization. Include routine preventive maintenance as recommended by manufacturer. Provide parts and supplies as used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Contractor acknowledges with bid submission that products and distributor channels are prescriptive in Communication Division 27 specifications. The Owner encourages new and innovative approaches, and welcomes "the latest state-of-the art components or the Bidder's standard components" as indicated in sub-paragraph C above. However, these are encouraged to be submitted as an alternate submission, as their rejection may result in disqualification of the entire proposal.

B. Notify Designer for an on-site visit to inspect material and equipment prior to installation.

C. Materials and equipment shall be new, undamaged, and shall be UL listed for its use.

D. Defects and damages of material shall be replaced. Furnish any new material as necessary and install the system at the Contractor's expense.

E. Furnish equipment and material samples when requested by the Owner's Representative, within 21 days of request.

F. Non-approved material and equipment must be removed from the jobsite.

G. Item referred to in singular number in these Specifications and Drawings shall be provided in quantities necessary to complete work.

H. Provide necessary tools and materials not specified in the parts list, (tie wraps, d-rings, screws, consumables (copper and fiber optic), hardware, etc.) and equipment, (ladders, hydraulic lifts, cable tuggers, storage containers, etc.) necessary to provide a complete and fully functional communications infrastructure system.

I. Equipment and materials specified shall be of the quality and manufacturer indicated. The equipment specified is based upon the acceptable manufacturers listed.

J. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to written approval by from Owner per the substitutions policy listed below.

K. Materials and methods shall comply in every way with above cited Standards and Codes.

PART 3 - EXECUTION

3.1 GENERAL

A. Device or equipment mounting heights indicated in the Specifications, Drawings, and/or documents are intended to provide general guidelines and are provided according to general industry standards. Such guidelines may not be exact or accurate and may or may not conflict with other trades installation without verification. Field verify all dimensions and heights with other contractors, trades, or any shop drawings and ensure that such mounting heights are indeed practical and feasible as not to conflict with other installation and construction. If conflicts are discovered at any time during the construction, report to Designer or Owner's Representative immediately for resolution.

B. If the contractor fails to provide such field verifications and failure results in erroneous installation, the contractor shall remedy such installation per Owner's Representative's direction at contractor cost.

C. Maintain clearances around electrical and mechanical equipment to allow access for maintenance per NEC and local codes.

D. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide maximum headroom and access for service and maintenance as possible.

E. Install all systems, materials, and equipment plumb and level, and parallel and perpendicular to building lines and other building systems and component. This condition applies to both exposed and concealed locations except where specifically indicated.

F. All devices, outlets, sleeves and conduits can be field located by Owner's Representative within 15' of the designed locations prior to rough-in without extra compensation.

G. Prior to start of work, racks and cabinets can be field located by Owner's Representative within 10' of the designed locations without extra compensation.

H. Install cabling, wiring, and equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

I. Contractor shall protect all copper and optical fiber cabling from physical damage. Copper and fiber optic cables shall not be exposed to forces or handling factors that will degrade performance, such as crushing, pull stressing, twisting, or damaging sheath materials. Contractor shall secure any unattended copper and optical fiber cable whether on reels, in boxes or during placement where it may be on the ground or in some other manner exposed to damage.

J. Contractor or manufacturer/assembler to install frames, patch panels and wiring blocks whether the components are fully populated with cables or not.

K. Contractor shall install all work as indicated on the drawings and specifications unless otherwise indicated. Contractor shall notify Engineer and Owner in the event field conditions or discovery exposes an issue that would result in the installed system not meeting the design intent or expressed level of performance.

3.2 EQUIPMENT INSTALLATION

A. Install equipment according to manufacturer's written instructions. Install equipment level and plumb. Install wiring and cabling between equipment and related devices.

B. Mounting: For equipment at walls, bolt units to wall or mount on structural steel channel strut bolted to wall. For equipment not at walls, provide freestanding racks fabricated of structural steel members and slotted structural steel channel strut. Use feet consisting of

C. 0.25 inch thick steel plates, 6 square inch, bolted to floor. Use feet for welded attachment of vertical posts not over 3 feet on center. Connect posts with horizontal U channel steel strut and bolt control equipment to channels.

D. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

E. Connections: Tighten wiring connectors, terminals, bus joints, and mountings, to include lugs, screws and bolts according to equipment manufacturer's published torque tightening values for equipment connectors. In absence of published connection or terminal torque values, comply with torque values specified in UL 486A and UL 486B.

3.3 UTILITY COORDINATION

A. All work associated with telecommunication utilities shall be installed in accordance with the standards and specifications established by the serving utility.

B. Contact telecommunication utilities as required to complete the specified work scope. Verify and coordinate work scope prior to commencement of installation.

3.4 PREPARATORY WORK

A. Review: Prior to all work of this division, Contractor shall perform a complete specification and drawing review and shall notify Designer and Everett Housing Authority DCE Telecom

B. If any discrepancies or conflicts found. This review shall include a check to assure all products are compatible with each other as to fit, form and function.

C. Inspection: Prior to all work of this division, carefully inspect the work of other trades and verify the completeness of such work to the point where communication work may commence in a proper and orderly manner. Do not begin work until all required preparatory work is complete.

D. Field Verifications: Prior to start of work, Contractor shall verify field conditions and dimensions that affect provision and/or installation of all telecommunication products and materials within this Division. Identify any condition that requires any disassembly, reassembly, relocation, demolition, cutting and patching required to provide work specified or indicated, including relocation and reinstallation of existing wiring and equipment. Contractor shall protect from damage any existing system, building component, facility component or equipment affected from Contractor's work. Extra charges for completion and contract time extension will not be allowed because of field conditions or additional work required for complete and usable construction and systems.

E. Information Gathering: Obtain final rough-in dimensions or other information as needed for complete installation of items furnished under other sections or by Owner. Contractor shall be responsible for being knowledgeable as to shape, size and position of openings required for material or equipment to be provided under this and other sections. Provide full information such that any work or openings by Contractor may be coordinated with other work and openings by others, and in a manner such that those work or openings may be provided and coordinated in advance. In case of failure by Contractor to provide proper notice containing this information, Contractor shall provide cutting, patching, repair and other works required to perform the specified work at no additional expense to Owner.

F. Verify site conditions and dimensions of equipment to ensure access for proper installation of equipment without disassembly that would void warranty.

G. Obtain and analyze catalog data, weights, and other pertinent data required for proper coordination of equipment support provisions and installation.

H. Discrepancies: Do not proceed with the work in the event of a discrepancy until resolved by the Owner's Representative.

I. Change Orders: Where changes of work require additional cost, prepare complete cost/credit breakdown herein specified and comply with change order requirements as specified in Division 1 and any Contract Documents.

3.5 MANUFACTURER DIRECTIONS

A. Apply, install and connect manufactured items or materials according to the recommendations, wiring diagrams and instructions of the manufacturer when such recommendations are not illustrated. Where such instructions are in conflict with the drawings and Specifications, notify the Owner's Representative for clarification before installing the work.

B. Keep at the site not less than one copy, in good condition, of the manufacturer's recommendations, wiring diagrams, instructions, or directions pertaining to work at the site. Inform involved personnel of the requirements and availability of manufacturer recommendations.

C. Upon request of the Owner's Representative, furnish copies of manufacturer's recommendations. If requested, secure approval of recommendations before proceeding with work.

3.6 COORDINATION

A. The drawings are diagrammatic and indicate generally the locations of material and equipment. These drawings shall be followed as closely as possible. Coordinate the work under this section with the architectural, structure, electrical, plumbing, heating and ventilation drawings, and drawings of other trades for exact dimensions, clearances and roughing-in locations. Cooperate with other trades in order to make minor field adjustments to accommodate the work of others.

B. Coordinate work with other trades providing equipment intended for connection to the communication system. Where connections or outlets are indicated for connection to such equipment, coordinate final equipment location prior to proceeding with work.

C. Coordinate work performed under this section with other trades performing work in the same area or where work under this section conflicts with work performed by other trades. Notify the General Contractor, AE and Owner where changes due to conflict are more than of a minor nature.

D. Coordinate with Civil Contractor or Engineer for underground work associated with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service if indicated.

E. Coordinate with Electrical Contractor for electrical work required to communication equipment. Provide power and connection requirements, including required voltage, phase and load information; wiring diagrams; outlet types and configurations; and exact outlet and equipment locations prior to start of work.

F. Coordinate the work with the General Contractor and Ceiling Contractor so that above ceiling work is completed, inspected and accepted by the Owner prior to ceiling installation. Final adjustments can be made later.

G. Coordinate all core drilling and penetrations of structural members, including structural walls, floor slabs, ceilings, beams and other members with the Architect or Structural Engineer prior to start of work.

H. Coordinate installation of devices and sleeves required to be set in poured-in place concrete and other structural walls or components to be put in place as they are constructed.

I. Sequence, coordinate, and integrate installations of materials and equipment for efficient flow of Work. Give particular attention to large equipment requiring positioning prior to closing in building.

J. If directed by the Owner's Representative, the Contractor shall, without extra charge, provide layouts of equipment and details of mounting methods for Designer's approval prior to installation to ensure proper execution of the work.

3.7 STRUCTURAL CONSIDERATION

A. Install equipment and all telecommunication products, including but not limited to racks, hardware, pathways, supports and cabling so as to properly distribute those weight loads on supporting building structural members provided under other Sections. Roof-mounted equipment shall be installed and supported on structural steel or roof curbs as appropriate.

B. Provide suspended platforms, strap hangers, brackets, shelves, stands or legs as necessary for floor, wall and ceiling mounting of equipment as required.

C. Provide steel supports and hardware for proper installation of hangers, anchors, guides, and other support hardware.

D. Structural steel and hardware shall conform to ASTM standard specifications. Use of steel and hardware shall conform to requirements of AISC Code of Practice: Section Five.

3.8 EXISTING SYSTEMS

A. Contractor shall be responsible for verifying all existing services prior to start of work in that area.

B. Contractor shall maintain all systems in full operational mode during the project except where indicated to be altered, changed or demolished. All work in areas where operational systems are present shall be fully coordinated with the Owner's Representative.

C. Contractor is not authorized to remove jumpers or patch cables. Removal of jumpers and patch cables shall be done by or at the direction of the Owner's authorized representative.

D. Contractor shall develop and provide a written work plan for work in any area with operating telecommunication equipment. It shall include a full method statement and schedule of anticipated work windows. Contractor shall secure approval of work plan by Owner's Representative and perform all work according to the written plan.

E. Active equipment to be maintained shall be tagged and/or locked-out during the entire work duration in each active area.

F. Contractor shall assume all costs and responsibilities of working in active operational areas, including those of planning and any resultant downtimes, and shall be responsible for any damage or interruption of systems or services. Contractor shall assume any costs, both direct and indirect, of any damages caused by their work to any existing system.

Contractor shall assume all costs of protecting and maintaining existing systems except where otherwise indicated in writing by Owner.

3.9 ON SITE OBSERVATIONS AND SAFETY MEASURES

A. During its progress, work shall be subject to observation by the Owner's Representative, Designer, and/or their representatives. The Designer has not been retained or compensated to provide design or construction administration services relating to the Contractor's safety precautions or to means, methods, techniques, sequences or procedures required for the Contractor to perform this work. The Contractor shall be totally responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be

limited to normal working hours. The duty of the Owner's Representative and Designer to conduct construction observations of the Contractor's performance is not intended to include review of the Contractor's safety measures; whether in, on, or near the construction site. It is the Contractor's responsibility to comply with any project or safety regulations. Contractor shall be responsible for providing such safety measures and consult with the appropriate authorities for interpretation whenever in doubt as to whether safe conditions do or do not exist or whether the Contractor is or is not in compliance with the regulations. Furthermore, the Contractor distinctly assumes all risk of damages or injury to any persons or property wherever located, resulting from any action or operation under this contract or in connection with the work.

3.10 BUILDING PENETRATIONS

A. Locate holes in advance where they are proposed in structural sections such as beams and girders. Obtain approval of the Owner's Representative and Structural Engineer prior to drilling through any type of structural member.

B. Coordinate with General Contractor and other disciplines for chases, slots, and openings in other building components during construction.

C. Cut holes larger than 1-1/2" with a diamond tipped core drill or concrete saw when penetrating masonry and concrete in new and existing structures. Holes smaller than 1- 1/2" in total diameter are permitted to use pneumatic hammer, hand or manual type hammer drills and impact drills. Holes larger than 1-1/2" in diameter or rectangular openings larger than 4 square inches are not allowed to use pneumatic hammers, hand or manual type hammer drills and impact drills without written permission from the Telecom Engineer of Record.

3.11 CUTTING AND PATCHING

A. Cut, remove, and legally dispose of selected materials including but not limited to material, equipment, devices, and other items required to be removed or demolished in performing the Work. Provide and maintain temporary partitions or dust barriers adequate to prevent spread of dust and dirt to adjacent areas

B. Protection of work: Protect structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed. During cutting and patching operations, protect adjacent installations. Patch finished surfaces and building components using new materials specified for original installation and experienced Installers.

3.12 CORE DRILLING

A. Core drilling to be avoided where possible. Where core drilling is unavoidable, locate required openings prior to coring. Coordinate all drilling work with General Contractor.

B. Coordinate openings with other trades and utilities and prevent damage to structural reinforcement.

C. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

D. Set sleeves prior to installation

3.13 FIRE STOPS AND ENCLOSURES

A. Maintain fire-resistance rating of walls, partitions, floors, ceilings or other fire separation barriers whenever work requires penetrations or openings for equipment. Provide and use approved methods and fire seal material and fittings to maintain the fire-resistance rating. Provide approved fire rated enclosures consisting of multiple layers of gypsum wall board or other approved materials to maintain the correct wall fire resistance rating for any communication panels or enclosures installed in fire rated walls.

B. Locate devices horizontally a minimum of 24” apart on opposing sides of a fire separation wall to maintain the fire rating of the wall.

C. Provide fire-stopping materials and methods in accordance with the project Specifications.

D. For projects where sprayed fireproofing is specified:
   1. Install clips, hangers, clamps, supports and other attachments to surfaces to be fireproofed prior to start of spray fire proofing work.
   2. Products such as conduit, cable tray, and other items that would interfere with proper application of fireproofing shall be installed after completion of spray fire proofing work.
   3. Any work or repairs necessary due to Contractor’s damage or disturbance of fireproofing shall be performed by the fireproofing contractor. All costs for this work and repair shall be paid by the Contractor responsible for the damage or disturbance.

3.14 ACCESS AND ACCESS PANELS

A. All materials and equipment that require inspection, replacement, repair or service shall remain readily accessible.

B. Provide access panels and/or doors as required to allow service of equipment components. Provide access panels where installed products require access and are concealed in floor, wall, furred space or above ceiling.

C. Access panels shall not be less than 24” x 24” in size.

D. Ceilings consisting of lay-in or removable splined tiles do not require access panels.

E. Locations of equipment requiring access shall be noted on record drawings.

F. Access panels shall have same fire rating classification as surface penetrated.

G. Where access panels, doors or other items are installed to provide ready access to telecom systems, provide a detailed schedule prepared in Everett Housing Authority Excel noting location, size and function of the covered system. This schedule shall be included in the Operations and Maintenance Manual.

H. Contractor is responsible for cleanup of debris on a daily basis. Cost of cleanup is the responsibility of the Contractor.

I. Provide for the removal from the site of spoils, debris, boxes, packaging, crates, and trash generated from the work.

J. During progress of work, remove equipment and unused material. Put building and premises in neat and clean condition. Perform cleaning and washing required to provide acceptable appearance and operation of equipment to satisfaction of Owner’s Representative.

K. Upon completion, cable contractor to vacuum utilizing a commercial HEPA filtration vacuum cleaner and clean floors, racks and equipment where work has been performed. This condition is intended but not limited to CNR, MDF, IDF rooms and rows and other cable room or rack areas and within cable trays in all areas.

L. After completion of Project, clean exterior surface of all equipment, Remove all concrete residue, dirt, and paint residue. This work shall be performed before final acceptance and punch walk by Owner.

3.15 INSTRUCTION PERIODS FOR OWNER’S PERSONNEL

A. Scope: Following installation of work, have representatives of installation tradesmen conduct demonstrations and instruction periods to demonstrate the proper operation of equipment or system;

and to point out locations of servicing points and required points of maintenance to Owner's Representative.

B. General Description of Instruction Periods: Each period shall include preliminary discussion, and presentation of information from maintenance manuals with appropriate reference to Drawings; followed by tours of building areas explaining operational methods, maintenance requirements, access methods, servicing and maintenance procedures and any available adjustments.

C. Scheduling of Instruction Periods: Notice of Contractor's readiness to conduct such instruction and demonstration shall be given Owner's Representative at least two (2) weeks prior to the instruction periods, and agreement reached as to the date at which the instruction periods are to be performed. Receive approvals of proposed date prior to making final arrangements.

3.16 STARTUP AND OPERATIONAL TESTING

A. Owner maintains right to have access to entire project site to prepare facility for occupancy and operation.

B. Completion of start-up and field testing shall be accomplished as a prerequisite for substantial completion. Operate and maintain systems and equipment until final acceptance by Owner.

C. Guarantees and warranties shall not begin until Owner's final acceptance of systems and equipment. Such acceptance requires complete systems startup and testing at minimum.

END OF SECTION 270000

SECTION 27 0526

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES:

A. Grounding and Bonding requirements, including grounding conductors, electrodes, plates, busbars, lugs and connectors and methods for all Communication Systems within the Data Center.

1.2 RELATED DOCUMENTS

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

B. All general provisions of Section 27 00 00 General Provisions for Communication Systems shall apply to this Section, unless otherwise noted. Where modified, the modification will supersede the original condition.

1.3 REFERENCES

A. All documents referenced in Section 27 00 00 General Provisions for Communication Systems are hereby incorporated by reference within this Section.
   1. Emphasis shall be placed on articles specifying grounding/earthing standards and procedures.

1.4 DESCRIPTION AND GENERAL SPECIFICATIONS

A. Provide all labor, materials, tools, equipment and services required to provide and place into satisfactory and successful operation a complete, fully functional and permanent grounding and bonding system for communications circuits, raceways, and cable trays as herein specified and/or shown on the Contract Documents.

B. Where indicated, provide coordinate with the Telecommunication Designer and Electrical Contractor for locations where the Telecommunication Grounding system interfaces or uses common elements of or with the Electrical Grounding system.

C. Electrical Contractor shall provide backbone bonding system and provide grounding busbars in telecommunication spaces and rooms. Telecommunication contractor shall provide grounding systems as described herein and on plans from equipment specified in Division 27 to the grounding busbars.

D. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the plans, but which are necessary to make a complete working ANSI/TIA/EIA and ISO/IEC compliant Grounding and Bonding system

E. Conduits, conductors, electrodes, busbars, fittings and other materials and appurtenances shall be UL listed, approved and suitable for the use and environment where installed.

F. Notify the Owner’s Representative at least two (2) full working days prior to covering of concealed communications work.

1.5 SYSTEM DESCRIPTION

A. Bond the following items to the building common bonding network (CBN) if present in the design.
   1. Communications system active equipment.
   2. PDU and surge protection equipment.

3. Raised floor systems.
4. Underfloor grounding grids for computer or telecommunications rooms.
5. Metallic raceway systems, including metallic cable trays.
6. Communications equipment enclosures (cabinets), racks or cross connect frames.
7. Broadband passive devices.
8. Metallic splice cases.
9. Metallic cable screens, armor or shields.
10. Metal cable conduit.
11. Grounding Electrode System.
12. Electrical service panels in entrance facilities, telecommunications and equipment rooms.
13. Busbars.
14. Exposed building steel that is within 6 feet of equipment racking systems.
15. Building steel extending to earth in outside-plant.
16. Related bonding accessories.

1.6 DEFINITIONS

A. The term “bonding” means the permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

B. The term “bonding conductor for telecommunications” means the conductor that interconnects the telecommunications bonding infrastructure to the building’s service equipment (power) ground.

C. The term “equipment bonding conductor” means the copper conductor extending from the equipment being grounded to the telecommunications main grounding busbar or the telecommunications grounding busbar. Equipment may be electronic equipment specified to be grounded, cable tray, ladder rack, equipment racks and cabinets, and the like.

D. The term “ground” means a conducting connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

E. The term “grounding electrode conductor” means the conductor used to connect the grounding electrode to the equipment grounding conductor, or to the grounded conductor of the circuit at the service equipment, or at the source of a separately derived system.

F. The term “grounding electrode system” means an electrode(s) as specified in ANSI/NFPA 70 (NEC), Article 250 Part H.

G. The term “telecommunications main grounding busbar” (TMGB) means a busbar placed in a convenient and accessible location and bonded by means of the grounded electrode conductor for telecommunications to the service equipment (power) ground. Only one TMGB per building.

H. The term Primary Busbar (PBB) in the most recent TIA 607-x is interchangeable with TMGB from older TIA 607-x revisions.

I. The term “telecommunications grounding busbar” (TGB) means a busbar placed in a convenient and accessible location and bonded by means of a grounding conductor for telecommunications to the telecommunications main grounding busbar or the telecommunications bonding backbone.

J. The term Primary Busbar (PBB) in the most recent TIA 607-C is interchangeable with TMGB from older TIA 607-x revisions.

K. The term Secondary Busbar (SBB) in the most recent TIA 607-C is interchangeable with TGB from older TIA 607-x revisions.

L. The term “rack bonding busbar’ (RBB) means a grounding busbar mounted within a rack or cabinet and bonded to the TGB/SBB

M. The term “telecommunications bonding backbone” (TBB) means the copper conductor extending from the telecommunications main grounding busbar to the telecommunications grounding busbar (TGB). A TBB originates at the TMGB, extends through the building using the telecommunication backbone pathways and connects to the TBG(s) in the telecommunication closets and equipment rooms.

N. The term “telecommunications bonding backbone interconnecting bonding conductor” (TBBIBC) means a conductor that interconnects the telecommunications bonding backbones.

1.7 ABBREVIATIONS AND ACRONYMS

A. See specification 27 00 00 General Provisions for Communication Systems Section 1.11 Abbreviations and Acronyms

1.8 SUBMITTALS

A. Submittals shall be prepared and delivered in accordance with Section 01 33 00 Submittal Procedures, Section 27 00 00 General Provisions for Communication Systems and Division 0 and Division 1 in sufficient detail to show full compliance with the specification.

B. Manufacturer’s Catalog Data shall be submitted for the following items at minimum:
1. Support materials and hardware for products specified in this Section.

C. Data shall include a complete list of parts, special tools, and supplies with source of supply.

1.9 QUALITY ASSURANCE:

A. Conform to all conditions within “Quality Assurance and Workmanship” in Section 27 00 00 General Provisions of Communications Systems.

PART 2 - PRODUCTS

2.1 GENERAL

A. All bonding conductors and connectors shall be listed for the purpose intended and approved by a Nationally Recognized Testing Laboratory (NRTL). Parts listed below cover a broad range of telecommunications grounding and bonding solutions, large and small. Adhere to the TIA-607-C requirements applying only those materials needed for this specific project.

2.2 GROUND CONDUCTORS

A. Size: #2/0 AWG, stranded extra flexible THW or THHN style cable with rubber jacket.

B. Size: #1 AWG THW or THHN

C. Size: #6 AWG green, THHN solid.

2.3 BUSBARS:

A. Meet BICSI and TIA-607-C requirements for network systems grounding applications.

B. Employ BICSI hole spacing.

C. Be made of high conductivity copper and tin-plated to inhibit corrosion.

D. Come pre-assembled with brackets and insulators attached for quick installation.

E. Use Panduit component labels, sold separately, to identify busbars to meet TIA/EIA-606.

F. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

G. Part Numbers:
1. GB2B0306TPI-1, 6 number of mounting positions with ¼" inch stud hole with 5/8" inch hole spacing and 3 number of position with 3/8" inch stud hole with 1" inch hole spacing
2. GB2B0312TPI-1, 12 number of mounting positions with ¼" inch stud hole with 5/8" inch hole spacing and 3 number of position with 3/8" inch stud hole with 1" inch hole spacing
3. GB4B0624TPI-1, 24 number of mounting positions with ¼" inch stud hole with 5/8" inch hole spacing and 6 number of position with 3/8" inch stud hole with 1" inch hole spacing
4. GB4B1028TPI-1, 28 number of mounting positions with ¼" inch stud hole with 5/8" inch hole spacing and 10 number of position with 3/8" inch stud hole with 1" inch hole spacing
5. LTYK, Busbar label kit includes one printed tag and on flame retardant cable tie

2.4 LUGS

A. Location: As required.

B. Provide standard approved lugs for grounding racks and cable tray.
1. #2/02. #6
2. Material: copper or alloy copper.
3. Connection type: compression
4. Hole type – 2-hole
5. Barrel type: Standard straight
6. Size: #3/0 using Orange die.
7. Approved Manufacturer: Gedney, Ilsco, Eritech or approved equal

C. Standard Product:
1. Recommended Product: Thomas & Betts 54211

2.5 H-TAPS

A. Copper H-tap with cover
1. Recommended Product: Burndy YH292CWC

2.6 BRONZE BONDING PIPE CLAMPS:

A. Used to ground copper code conductor to water pipe or copper tube.

B. Cast from high strength, electrolytic bronze to provide reliable grounding connections.

C. Plated steel screws providing high strength and inhibit corrosion.

D. UL Listed for grounding and bonding with AWG conductor size and suitable for direct burial or encasement in concrete.

E. Owner approved manufacturers:
1. Panduit
2. Owner approved equivalent

F. Part numbers:
1. KP1-C; For pipe range 1/2 – 1 inch and conductor size range #10 SOL - #2 STR
2. KP2-L; For pipe range 1 1/4 – 2 and conductor size range #10 SOL - #2 STR

2.7 BRONZE BONDING CLAMPS FOR CONDUIT:

A. Used to ground copper conductor parallel or at a right angle to a rod, tube, or pipe.

B. Made from high strength, electrolytic cast bronze.
   A. High strength silicon bronze hardware provides long term reliable assembly.

C. Accommodates a wide range of pipe, tube, rod and conductor sizes – minimizes inventory.

D. UL Listed for grounding and bonding with AWG conductor and suitable for direct burial in earth or concrete.

E. Owner approved manufacturers:
   1. Panduit
   2. Owner approved equivalent

F. Part numbers:
   1. GPL-8-Q; For pipe size inches 1/2 or 3/4 and conductor size range AWG #8 SOL - #4 SOL
   2. GPL-14-X; For pipe size inches 1 and conductor size range AWG #8 SOL - #4 SOL
   3. GPL-22-X; For pipe size inches 1 1/4 and conductor size range AWG 2/0 SOL – 250 kcmil
   4. GPL-28-X; For pipe size inches 1 1/2 and conductor size range AWG 2/0 SOL – 250 kcmil
   5. GPL-34-3; For pipe size inches 2 and conductor size range AWG 2/0 SOL – 250 kcmil

2.8 COMMUNICATION GROUNDING RODS:

A. Material: Copper-clad steel.

B. Size: 3/4-inch by 8 feet long.

C. Standards: Meet requirements of ANSI®/UL 467-1984, CSA, and ANSI/NEMA GR-1.

D. Owner approved manufacturers:
   1. Erico
   2. Burndy
   3. T&B
   4. Lyncole
   5. Owner approved equivalent

2.9 ELECTROLYTIC GROUND RODS:

A. Where standard ground rods do not have acceptable levels of conductivity (typically greater than 5 ohms resistance) to earth due to local soil conditions, electrolytic systems may be considered.

B. Such systems shall meet the following:
   1. Be comprised of a hollow stainless steel or copper tube 10 feet or longer and filled with a mixture of hygroscopic electrolytic salts.
   2. Function as an active grounding system by absorbing moisture out of the air and constantly leaching and electrolytic solution into the surrounding soil to maintain high conductivity.
   3. Rod shall be encased in a conductive, non-corrosive carbon based back fill material.
   4. Provide low resistance to ground.
   5. Provide season to season stability.
   6. Be maintenance-free for 30 years.
   7. Contain no hazardous materials or chemicals.

2.10 TELECOMMUNICATIONS BONDING BACKBONE (TBB) GROUNDING CONDUCTORS:

A. To be bare or insulated copper, of minimum conductor size #6 AWG and sized at 2 kcmil per linear foot up to a maximum size of 750 kcmil.

B. Where un-insulated, to be identified with green tape at termination location.

C. Labeled in accordance with recommendations set forth in ANSI/TIA-606-B (March 2012) Administration Standard for Telecommunications Infrastructure.

D. Owner approved manufacturers:
1. Southwire
2. Owner approved equivalent

2.11 TWO-HOLE, LONG-BARREL COMPRESSION LUGS FOR CODE CONDUCTORS:

A. Meets TIA-607-C requirements for network systems grounding applications.

B. Tested by Telcordia – meets NEBS Level 3 with AWG conductor.

C. UL Listed and CSA Certified with AWG conductor for use up to 35 KV and temperature rated 90°C when crimped with Panduit and specified manufacturers' crimping tools and dies.

D. Color-coded barrels marked with Panduit and specified manufacturers' die index numbers for proper crimp die selection.

E. Have long barrel to maximize number of crimps and provides premium wire pull-out strength and electrical performance.

F. Have an "inspection window" over tongue to visually assure full conductor insertion.

G. Tin-plated to inhibit corrosion.

H. Available with NEMA and BICSI hole sizes and spacing.

I. Owner approved Manufacturers for lugs:
1. Panduit
2. Owner approved Equivalent

J. Part Number:
1. LCC Series, Panduit two hole compressing lugs for code conductors in BISCI hole spacing

2.12 CODE/FLEX CONDUCTOR H-TAPS

A. Used to tap into continuous conductors as a splice or pig tailing.

B. Each HTAP terminates a wide range of conductor sizes and combinations of code and flex conductors Class G, H, and I to suit a variety of applications.

C. Slotted design allows quick and easy assembly of conductor to HTAP using

D. Three Panduit 94V-0 cable ties included.

E. Tap grooves are separated from one another allowing them to function independently so HTAP can be used with a single or multiple taps providing maximum design and installation flexibility.

F. Color coded and marked with Panduit die index numbers for proper crimp die selection.

G. UL Listed and CSA Certified with AWG conductor for applications up to 600 V when crimped with Panduit and specified manufacturers' crimping tools and Panduit crimping dies.

H. Tin plated to inhibit corrosion.

I. Come available with an assortment of clear covers with integrated label fields.

J. Owner approved Manufacturers for HTAPs and clear covers:
1. Panduit
2. Owner approved Equivalent

K. Part Numbers:
1. HTCT Series, Panduit HTAPs. Selected according AWG size of run and tap conductors
2. CLRCVR Series, Panduit clear covers for HTAPs. Selected according to HTAP being covered.

2.13 CODE CONDUCTOR, THIN WALL, TIN-PLATED C-TAP (SPLICE)

A. For copper-to-copper tapping splicing or pig tailing.

B. Wide wire range-taking capability minimizes inventory requirements.

C. Color-coded for proper crimp die selection.

D. Ribbed design provides high strength.

E. Made from high conductivity wrought copper.

F. Tin-plated to inhibit corrosion and oxidation.

G. UL Listed and CSA Certified with AWG conductor to 600 V and temperature rated to 90°C when crimped with Panduit and specified manufacturers' crimping tools and dies.

H. Owner approved Manufacturers for C-TAPs:
1. Panduit
2. Owner approved Equivalent

I. Part Numbers:
1. CTAPF Series, Panduit C-TAPs. Selected according AWG size of conductors being spliced

2.14 IEEE UNIVERSAL BEAM GROUNDING CLAMP

A. For bonding structural steel (ex: I-beams) into bonding network

B. Universal, fits on a wide range of standard (angled) and wide flange (parallel) structural steel beams.

C. Provide a mounting pad suitable for a two-hole compression lug.

D. Install quickly and easily with standard 1/4" inch key hex wrench tooling.

E. UL 467 Listed and CSA 22.2 Certified for grounding and bonding suitable for direct burial in earth or concrete.

F. Comply with vibration tests per MIL-STD-202G (METHOD 201A).

G. Owner approved Manufacturers for beam grounding clamps:
1. Panduit
2. Owner approved Equivalent

H. Part Number:
1. GUBC500-6, Panduit Universal Beam Grounding Clamp for copper conductor sizes ranging from #6AWG to 500kcmil and flange thickness from 0.25” inch to 0.675” inch. Stud size is ½” inch with hole spacing for two hole lug being 1.75” inch and thread size from ½ to 13.

2.15 SPLIT BOLT FOR BONDING CABLE TRAYS:

A. Made from high strength copper alloy to resist corrosion and provide premium electrical and mechanical performance.

B. Wire range-taking capability minimizes inventory requirements.

C. Nut hex provides correct fit with socket, box, or open end wrenches resulting in proper torqueing of electrical connection.

D. Pressure bar provides secure connection on a full range of conductor combinations used with each connector assuring premium wire pull-out strength.

E. UL Listed and CSA Certified with AWG conductor for use up to 600 V and temperature rated 90°C.

F. Be available in tin-plated version for bonding to galvanized wire baskets and Flex Tray.

G. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

H. Part Numbers:
1. SBC3-C, Panduit split lug for #8AWG to #4AWG code conductors
2. SBCT3-C, Panduit split lug for #8AWG to #4AWG code conductors – tinned for use with galvanized basket tray delivery systems

2.16 AUXILIARY CABLE BRACKETS (CONDUCTOR PATHWAY)

A. Used for mounting telecommunications bonding conductors outside of cable tray.

B. Maintain minimum 2" inch separation between bonding conductors and other types of cabling per TIA 607-C.

C. Bonds ladder rack, wire basket sections together without drilling holes or applying other split-bolt clamps.

D. Supports grounding conductors in the telecommunications room, allows separation of grounding conductors from other cables.

E. Holds up to four conductors in sizes up to 750 kcmil.

F. Bonds to 1" inch and 2" inch ladder rack rails.

G. Paint piercing teeth provide electrical continuity between cable pathway sections while minimizing

H. Front and back mounting screw options allow easy installation and visual inspection.

I. Mounted above or below the cable pathway system for flexibility.

J. Meet requirements TIA-607-C.

K. Have available bonding jumper kits to bond sections of basket tray or ladder rack.

L. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

M. Part Numbers:
1. GACB-2, Auxiliary cable bracket; 1.63” inch (41.4mm) width, 3.95” inch(100.3mm) height, 5.22” inch (132.6mm) depth; provided with on mounting screw.

2. GACBJ612U, Auxiliary cable bracket jumper for bonding pathway sections: #6AWG (16mm2); 12.0” inch (305mm) length; factory terminated on both ends with straight, two-hole, long barrel compression lugs; provided with .16oz. (5cc) of antioxidant and four mounting s screw.

2.17 VERTICAL GROUNDING BUSBARS FOR NEW INSTALL RACKS AND CABINETS

A. Provides clean bond to any rack mounted equipment regardless of whether or not equipment has an integrated grounding terminal.

B. Bonds up to 58 RU per rack.

C. Comes in EIA universal mounting hole pattern.

D. Complies with US and International grounding requirements.

E. Comes in threaded rail and cage nut versions.

F. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

G. Part Numbers:
1. RG S134-1Y, Grounding strip for threaded rails: 78.65” inch (2m) length: 67” inch (17mm) width: 0.05” inch (1.27mm) thickness; provided with 16 oz. (5cc) of antioxidant, one grounding sticker and three each #12-24 x ½” inch and M6 x 12mm thread-forming screws
2. RG S134B-1, Grounding strip for use with cage nut rail fasteners: 78.70” inch (2m) length: 67” inch (17mm) width: 0.05” inch (1.27mm) thickness: provided with. 16oz (5cc) of antioxidant, one grounding sticker, three cage nut bonding studs, eight #12-24 bonding nuts and three strip clips

2.18 RACK BONDING CONDUCTOR KITS (RBC)

A. Bonds the rack or cabinet to the telecommunications grounding busbar (TGB).

B. Jumper kit available with both ends factory terminated to provide a bolt-on solution.

C. Jumper kit available with one end factory terminated to attach to the rack or cabinet; free end accommodates unique length requirements.

D. Engineered to comply with US and international grounding requirements.

E. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

F. Part Numbers:
1. GJ672UH, terminated on both ends for smaller telecommunications rooms where racks have individual connections directly to the TMB. One 72" inch length #6 AWG green wire with yellow horizontal stripe. Jumper is pre- terminated on one end with LCC6-14JAWH-L and the other end with LCC6- 14JAW-L. Comes in lengths 72" inch, 96" inch, 120" inch, 144" inch, 168" inch, 192" inch, 216" inch, 240" inch, 264" inch, and 288" inch. For other lengths substitute 72" inch in part number with desired length
2. GJS6120U, terminated on one end for larger telecommunications rooms where racks are individually bonded to underfloor or overhead bonding backbone with an HTAP connection. One 120" inch length #6 AWG green wire with yellow horizontal stripe. Jumper is pre-terminated on one end with LCC6-14JAW-L. For 180" inch length substitute "120" inch in part number with "180"

3. HDW1/4-KT, Stainless steel mounting hardware for busbar; two 1/4-20 hex bolts, two 1/4-20 hex nuts, four 1/4 flat washers and two 1/4 Belleville compression washers. Mounting hardware for rack or cabinet; two #12-24 thread-forming screws and two M6 thread-forming screws.
4. HDW3/8-KT, Stainless steel mounting hardware for busbar; two 3/8-16 hex bolts, two 3/8-16 hex nuts, four 3/8 flat washers and two 3/8 Belleville compression washers. Mounting hardware for rack or cabinet; two #12-24 thread-forming screws and two M6 thread-forming screws
5. HDW1/4-A-KT, Stainless steel mounting hardware for busbar; two 1/4-20 hex bolts, two 1/4-20 hex nuts, four 1/4 flat washers and two 1/4 Belleville compression washers. Mounting hardware for rack or cabinet; two #10-32 thread-forming screws and two M5 thread-forming screws
6. HDW3/8-A-KT, Stainless steel mounting hardware for busbar; two 3/8-16 hex bolts, two 3/8-16 hex nuts, four 3/8 flat washers and two 3/8 Belleville compression washers. Mounting hardware for rack or cabinet; two #10-32 thread-forming screws and two M5 thread-forming screws

2.19 ELECTROSTATIC DISCHARGE (ESD) PORT KITS AND WRIST STRAP

A. For dissipating electro-static buildup prior to maintenance work on network equipment.

B. Accommodate standard ESD wrist strap 4mm plug.

C. Wrist strap provides rapid and continuous drain of electrostatic charge between a person and the surface that the wrist strap is bonded to, thus preventing damaging static discharge into equipment.

D. Can be mounted to front or back of rack or cabinet for convenient access.

E. Bent 45°, acts as a hook to hold wrist strap.

F. Two-hole configuration provides anti-rotation and prevents loss of bond.

G. Barrel permanently marked with the protective earth (ground) symbol.

H. Engineered to comply with US and International grounding requirements.

I. Versions for threaded racks rails or cabinet cage nuts.

J. Owner approved Manufacturers:
1. Part Numbers:
2. RGESD2-1, For #12-24 or M6 rail fasteners: Two-hole ESD port with 5/8" inch hole spacing; provided with an ESD protection sticker, .16 oz. (5cc) of antioxidant, and two each #12-24 x 1/2" inch and M6 x 12mm thread-forming screws
3. RGESD2B-1, For cage nut rail fasteners: Two-hole ESD port with 5/8" inch hole spacing; provided with an ESD protection sticker, .16 oz. (5cc) of antioxidant, two cage nut bonding studs and two #12-24 bonding nuts RGESDWS, Adjustable fabric ESD wrist strap with 6' coil cord, banana plug, 1 megohm resistor and 4mm snap.

2.20 EQUIPMENT JUMPER KITS (UNIT BONDING CONDUCTOR OR "UBC")

A. Ground large rack mounted equipment that has built-in grounding pads or terminals.

B. Bond network equipment to grounding strip or grounding busbar.

C. Jumper kit available with both ends factory terminated to provide a bolt-on solution.

D. Jumper kit available with one end factory terminated to attach to the grounding strip or grounding busbar; free end accommodates unique equipment terminations.

E. Use jumpers with 90° bent lug, on grounding strip side, for high density grounding requirements up to one ground point per RU.

F. Use jumpers with 45° bent lugs, on grounding strip side, for improved cable management.

G. Engineered to comply with US and International grounding requirements.

H. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

I. Part Numbers:
1. GJS6 series, #6 equipment jumper factory terminated on one end for switches, cabinets and 4 post racks. Exact part number depends on length
2. RGE series, Equipment factory terminated jumpers terminated on both ends. Exact part number depends on AWG size, length and angle of two hole lugs

2.21 SURGE SUPPRESSOR JUMPER KIT

A. Bonds power or data line surge suppressor to grounding strip or grounding busbar.

B. Both ends factory terminated to provide a bolt-on solution.

C. Engineered to comply with US and International grounding requirements.

D. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

E. Part Number:
1. SSGK-1, #10 AWG (6mm²) jumper; 24" inch (.61m) length; factory terminated on both ends; one-hole lug on surge suppressor to two-hole lug on grounding strip/busbar side; provided with .16 oz. (5cc) of antioxidant and two each #12-24 x 1/2" inch, M6 x 12mm, #10-32 x 1/2" inch and M5 x 12mm thread-forming screws

2.22 ARMORED CABLE GROUNDING KIT

A. Provides a secure bond to the armor sheath on indoor and indoor/outdoor fiber optic cables at both cassette and enclosure ends.

B. Worm-gear design evenly distributes forces across the armor

C. Made from steel and aluminum material is compatible with common armor for long term reliability.

D. Black insulating cover protects and hides the connection for an aesthetically pleasing work area.

E. Complies with industry requirements ensuring a high level of reliability and safety.

F. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

G. Part Numbers:
1. **ACG24K,** #6 AWG (16mm2) jumper for armored cable diameter up to 0.84" inch (21.3mm); 24" inch (609.6mm) length; factory terminated on one end with LCC6 two-hole copper compression lug and the other end with grounding terminal; provided with two each #12-24 and M6 thread-forming screws and a black polypropylene terminal cover
2. **ACG24K-500,** #6 AWG (16mm2) jumper for armored cable diameter 0.85" inch (21.3mm) to 1.03" inch (26.2mm); 24" inch (609.6mm) length; factory terminated on one end with LCC6

two-hole copper compression lug and the other end with grounding terminal; provided with two each #12-24 and M6 thread- forming screws and a black polypropylene terminal cover

3. **ACGK,** Armored cable grounding kit with one grounding terminal for #6 AWG and one #10 mechanical clamp, 9/16" inch – 1 1/16" inch diameter range

2.23 MISCELLANEOUS BONDING ACCESSORIES:

A. Anti-oxidation Paste for Copper to Copper and Copper to Steel Connections

B. Green thread-forming bonding screws for bonding smaller equipment on threaded rack rails.

C. Green bonding cage nuts from bonding smaller equipment on cage nut rails.

D. Thread forming screws for bonding two hole lugs to vertical busbars on threaded rack rails.

E. Green paint piercing grounding washers for assuring electrical continuity between painted parts of equipment racks as described in TIA 607-C Standard.

F. Bonding hardware kits (studs) for forming low-resistance bond between the rack or cabinet and painted rack mounted appliances and equipment.

G. Owner approved Manufacturers:
1. Panduit
2. Owner approved equivalent

H. Part Numbers:
1. CMP-300-1, Contact aid for copper-to-copper and copper-to-steel connections, 8 oz. Operating temperature range -40°F (-40°C) to 350°F (177°C). Good for all voltages and suitable for grounding. Also used for anti-seizing thread lubricant
2. RGTBSG-C, Green thread-forming bonding screw, #12-24 x 1/2" inch for mounting smaller equipment and bonding to rack/cabinet racks through equipment mounting flange
3. RGTBS1032G-C, Green thread-forming bonding screw, #10-32 x 1/2" inch for mounting smaller equipment and bonding to rack/cabinet racks through equipment mounting flange
4. CNB4K, Green bonding cage nut, includes 4 #12-24 bonding cage nuts (.06 – .11 thick panel) and 4 #12-24 x 1/2" inch bonding screws with #2 Phillips/slotted combo hex head (use 5/16" or 8mm socket). Ideal for patch panel applications
5. CNBK, Green bonding cage nut, includes 4 #12-24 bonding cage nuts (.06 – .11 thick panel) and 4 #12-24 x 1/2" inch bonding screws with #2 Phillips/slotted combo hex head (use 5/16" inch or 8mm socket). Ideal for patch panel applications
6. RGTS-CY, Thread-forming grounding screw, #12-24 x 1/2" inch for bonding two-hole grounding lugs to rack/cabinet vertical busbars
7. RGTS1032-C, Thread-forming grounding screw, #10-32 x 1/2" inch for bonding two-hole grounding lugs to rack/cabinet vertical busbars
8. RGW-100-1Y, 100 paint piercing bonding washers for 3/8" inch (M8) stud size;
9. .875" inch (22.2mm) O.D.; provided with .16 oz. (5cc) of antioxidant
10. TRBSK, Bonding stud kit for threaded #12-24 rail fasteners; includes 25 bonding studs and 50 bonding nuts for bonding painted equipment and appliances to rack/cabinet rails and vertical busbars
11. CGNBSK, Bonding stud kit for cage nut rail fasteners; includes 25 bonding studs and 50 bonding nuts for bonding painted equipment and appliances to rack/cabinet rails and vertical busbars

2.24 SURGE PROTECTION:

A. Indoor Building Entrance Terminal; 100 and 200 Pair

B. 110 connector input and output; accepts 22-26 AWG wire

C. Equipped with an Internal 26 AWG Fuse Link

D. External Ground Connectors accept 6-14 AWG wire

E. Internal splice chamber and cover over incoming and outgoing connections and protection modules

F. Exceeds UL497 Primary Protection Standards

G. Stackable to allow for future service

H. Removable door

I. Part Number:
   1. For 100 Pair: 1880ENA1/NSC-100
   2. For 200 Pair: 1880ENA1/NSC-200

J. Surge Protection Modules:
   1. 5-Pin Protection Units Gas Tube 350V
   2. Part Number: 3B1E
   3. 5-Pin Protection Units Gas Solid State 300V
   4. Part Number: 3B1S-300
   5. Meet or exceed Telcordia Standards

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.

B. All work shall comply with applicable safety rules and regulations including OSHA and state safety regulations. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.

C. All work shall comply with the standards, references and codes listed in PART 1 -- REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.

D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.

E. The complete earthing systems shall be complete from the grounding electrode(s) to each point of connection to telecommunication, network or server equipment or metal component surface.

F. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.

G. Install the grounding and bonding system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA/EIA and other references listed in Part 1 — References, above.

H. All bonding conductors shall be insulated and copper. The minimum bonding conductor size shall be #6 AWG. The telecommunications bonding conductor shall be sized in accordance with Table 1 below from TIA-697B. All conductors #6 AWG and smaller shall be provided with green-colored insulation.

TABLE 1

Sizing of the TBB	
TBB length in feet (meters)	**TBB Size (AWG)**
Less than 13 (4)	6
14-20 (4-6)	4
21-26 (21-26)	3
27-33 (27-33)	2
34-41 (34-41)	1
42-52 (42-52)	1/0
53-66 (53-66)	2/0
67-84 (67-84)	3/0
85-105 (85-105)	4/0
106-125 (106 – 125)	250 kcmil
126-150 (126-150)	300 kcmil
151-175 (151-175)	350 kcmil
176-250 (176-250)	500 kcmil
251-300 (251-300)	600 kcmil
Greater than 301 (91)	750 kcmil

I. The grounding and bonding infrastructure system shall not make use of the building plumbing system, unless required to do so by the NEC.

J. The entire grounding path from each final equipment connection to earth shall be able to be inspected visually.
   1. EXCEPTION: Where indicated on drawings to be direct-buried in earth or within walls or raceways.

K. Coordinate the installation of the grounding and bonding system with the electrical power distribution system grounding infrastructure.

L. Where a telecommunications metal pathway or raceway contains an expansion joint, each side of the expansion fitting or gap shall be bonded to provide an electrically continuous path to ground.

M. The system shall provide an equipment ground connection (bonds) from the premises entrance facility and outside-plant earthing system to each telecommunication room telecommunication ground busbar, through the racking systems to bond the network equipment.

N. Label elements of the communications bonding network according to guidelines defined in TIA-607-C and ANSI/TIA 606-B.

O. Contractor shall be completely responsible for the installation and testing of the complete grounding and earthing system and shall be knowledgeable of all standards, codes, installation and testing methods of those systems. The system delivered to Everett Housing Authority shall be a fully functioning, standards-compliant earthing system and shall be free of any conflicts or discrepancies.

3.2 INSTALLATION OF BONDING CONDUCTORS

A. Where practicable, install telecommunication bonding, telecommunication bonding backbone conductors, telecommunications bonding backbone interconnecting bonding conductors, equipment bonding conductor and all other grounding and bonding conductors in a manner, so they are routed horizontal to and downward toward the grounding electrode for the telecommunication bonding system.

B. Install all bonding and grounding cabling such that no bend forms an included angle of more than 90 degrees or has a radius of less than 8”.

C. Maintain a minimum distance of 12" between any bonding or grounding conductor and any direct-current power cabling, electrical service entrance or feeder cables, or any high- frequency cabling, even where such conductors or the bonding conductors are enclosed in metallic conduit.

D. Avoid placing bonding conductors in ferrous metallic conduit. Where necessary to place bonding conductors in ferrous metallic conduit that exceeds 3 ft. in length, each conductor shall be bonded to each conduit end with approved fittings and minimum #6 AWG bonding conductor to each conductor.

E. All bonding conductors shall be continuous and routed in the shortest possible path and at right angles to building lines, unless noted or indicated otherwise.

F. Where routed along cable tray pathways, install telecommunication bonding backbone cable or bonding conductors on underside and at edge of tray nearest the most common access area. Fasten to tray with approved “L” connectors at not less than 36” intervals.

G. Where routed along open pathways utilizing hooks or straps, install telecommunication bonding backbone cable or bonding conductors below telecommunication backbone cabling and so bonding cable is accessible from below. Fasten to hangar support with approved connector at not less than 36” intervals.

H. Grounding conductors shall not decrease in size as the earthing path moves toward the grounding electrode.

I. Splices within a Telecommunication Bonding Backbone (TBB) shall not be permitted without prior approval of the Designer. Taps from the TBB riser to lateral TBB conductors and where otherwise indicated on the Drawings shall be permitted. All such taps shall utilize irreversible compression-type connectors, exothermic welding or an approved equal connection method. All joints shall be adequately supported and protected from damage.

J. Whenever two or more vertical TBBs are used in a building, the TGBs shall be interconnected at the top of each riser and at every third floor with a Telecommunications Bonding Backbone Interconnecting Bonding Conductor (TBBIBC), in accordance with ANSI/TIA/EIA-607 and the NEC.

K. Each telecommunications bonding conductor shall be marked appropriately by a distinctive green color. Where conductor insulation is other than green in color, securely mark each conductor with color-coded green marking tape within 6 inches of each termination or point of connection; and where conductor is not installed in conduit, at a minimum of 8 foot intervals to provide ready identification.

L. Each telecommunications bonding conductor shall be labeled. Labels shall be located on conductors as close as possible to point of termination and be oriented so they may be easily read. Labels shall nonmetallic and include at a minimum the following text “WARNING! TELECOMMUNICATIONS

BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!" Label each TMGB with "TMGB" and each TGB with "TGB". Refer to Drawings for additional labeling instructions.

3.3 TELECOMMUNICATION ROOM GROUNDING

A. This paragraph shall be considered to include, but is not limited to the following Everett Housing Authority cable rooms:

B. Everett Housing Authority cable rooms are Telecommunication Rooms as defined in TIA standards documents. Refer to Section 27 00 00 for the list of applicable ANSI/TIA Telecommunication Standards documents.

C. Provide ground system as specified on drawings and as described herein.

D. Each telecommunications room shall be served by at least one (1) dedicated TGB located within that room or space.

E. Within each room the following items at a minimum shall be connected to the TGB within that room.
1. Exposed building steel
2. Equipment racks and cabinets
3. Cable tray and metal pathways
4. Telecommunication Equipment Bonding Conductors (TEBC)
5. Telecommunication Bonding Backbone (TBB)

F. Telecommunications Rooms and Telecommunications Grounding Busbar (TGB)
1. The TGBs shall have a tinned surface to inhibit oxidation and be sized according to the anticipated number of bonded connections that will be needed.
2. TGBs shall be sized according to the anticipated number of bonded connections needed.
3. TMGs shall have tinned surfaces to restrain oxidation and be cleaned and antioxidant paste applied prior to fastening conductors.
4. Connectors on backbone and rack/cabinet bonding conductors which attach to TGB shall be of two-hole, long-barrel compression lugs of the LCC series.
5. Bond the building steel within six feet of the communications grounding system.
6. Racks and cabinets shall have individual Rack Bonding Conductors bonding to the Telecommunications Equipment Bonding Conductor (TEBC) or underfloor Supplemental Bonding Grid. Daisy chaining or serial connections of one rack cabinet to another will not be accepted.
7. Rack Bonding Conductors (RBC) or above rack row grounds (TEBC) shall be installed to maintain a minimum of 2" inch separation from cable, power or communications.
8. Install auxiliary conductor brackets to maintain the segregation of cables in Telecommunications rooms may lend themselves to the installation of Auxiliary Conductor Brackets for routing bonding conductors outside of, yet parallel to ladder rack or basket tray.
9. Bonding conductor support systems like auxiliary brackets shall be spaced no further apart than three foot intervals.
10. This illustration below depicts general location and layout of the telecom room and associated bonding connections into the TGB.

3.4 WIRE BASKET TRAYS AND LADDER STYLE TRAYS

A. Ground as specified on drawings

3.5 GROUNDING BUSBARS

A. Connection of conductors bonding telecommunication equipment to the telecommunications busbar (TMGB or TGB) shall utilize two-hole compression-type lugs, unless noted otherwise.

3.6 GROUNDING OF EQUIPMENT AND MATERIALS

A. Within each room or space containing a TMGB or TGB, all metallic raceways for communication cabling shall be bonded to the TMGB or TGB.

B. Within each telecommunication room, entrance facility, equipment room or other telecommunication space, bond all equipment racks and cabinets, all ladder racks and cable trays, and all other materials or equipment identified as requiring bonding on the Drawings, to the TGB or TMGB within that space.

C. Remove paint to bare metallic surface for all painted surfaces at point of bonding.

D. Where a backbone cable incorporates a shield or metallic member, such shield or metallic member shall be connected to the TMGB or TGB. Approved fittings and methods shall be used for connection to the shield or metallic member to the grounding conductor.

E. The metallic sheath of outside plant (OSP) communication cables entering a building shall be grounded as close as practicable to the point of entrance or shall be interrupted as close to the point of entrance as practicable by an insulating joint or equivalent device.

F. The point of entrance shall be considered to be at the point of emergence through an exterior wall, a concrete floor slab, or from a grounded rigid metal conduit or an intermediate metal conduit grounded to an electrode in accordance with Section 800- 40(b). See NEC Article 800, “Communications Circuits”.

G. Contractor shall bond the cable shield to the TMGB or to the protection frame ground as indicated.

H. Bonding within Racks and Cabinets
   1. Racks and Cabinets shall be bonded into the communications bonding network with conductors of #6 AWG or larger.
   2. Depending on size of the telecommunications room, Rack Bonding Conductors (RBC) may bond to underfloor or overhead grounding conductors, or for smaller TRs 4-5 racks or less, may go directly from the rack to the wall mounted busbar.
   3. Racks, cabinets and similar enclosures shall not be bond serially or daisy- chained. Bond racks and cabinets with an RBC to the grounding system.
   4. Newly installed racks and cabinets shall have vertical grounding busbars installed along one rail to provide a clean bonding landing point for rack mount equipment.
   5. Painted components of racks/cabinets shall be assembled using serrated grounding washers and thread-forming screws as per TIA 607-C to ensure electrical continuity between the different parts of the rack/cabinet.
   6. Larger equipment, such as chassis switches, with integral grounding terminals or pads shall be bonded to the vertical busbar with equipment grounding kits attached to those terminals and bonding them to the rack-mounted busbars.
   7. Where two metallic surfaces are bonded together, clean the contact areas of paint or oxidation and apply film of anti-oxidation compound between surfaces prior to bonding.
   8. Cable fittings shall be of two hole (LCC series) compression-type. Mechanical screw-lugs on racking systems will not be accepted.
   9. Screws used to affix compression lugs to rack-mounted vertical busbars shall be of the thread forming type made specifically for electrical bonding.
   10. Smaller equipment such as servers, Top of rack switches, not having integral grounding pads are bonded to the rack through the equipment mounting flanges using green thread forming grounding screws with serrations under the head that are built to that purpose. Such equipment shall have minimally one grounding screw per piece of equipment.
   11. Technicians servicing active equipment to wear a properly grounded wrist strap to dissipate ESD charges prior to touching any Owner active equipment.
   12. The following illustration demonstrates how the racks shall be bonded:

3.7 FIELD QUALITY CONTROL

A. Visually verify continuity of communications bonding system from equipment, through racking systems, to overhead or underfloor backbone to the wall mounted busbar in that telecommunications room.

B. Verify the use of appropriate bonding accessories in the racking systems such as grounding washers, thread-forming grounding screws and the presence of electro-static discharge ports and wrist straps within reach of the equipment to be maintained.

C. On Greenfield projects involving installation of a building-wide telecommunications backbone, visually verify the bonding system through to entrance facility and check for properly sized and installed grounding equalizer conductors between separate backbones as described earlier in this Section.

D. During inspections contractor shall verify compliance with the requirements specified in this document and compliance with the regulatory references Standards and Codes cited.

E. Opens or gaps in the bonding system during final inspections will be recorded and remedied.

F. During inspections, check the grounding and bonding system conductors and connections for tightness and proper installation.

G. Test 10 percent of the bonded connections within the grounding system for resistance. Tests on either side of a compression or exothermic bond shall be less than 0.2 of ohms of resistance.

H. Bonded joints to be tested to be randomly identified by a representative of the Owner.

I. Test system at bonded points indicated and provides results in report form.

J. Failing bonds shall be remedied by installation contractor at contractor's expense.

END OF SECTION

SECTION 271323

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Optical fiber backbone cable, terminations, fittings, appurtenances, related hardware, testing, labeling and documentation.

1.2 REFERENCES

A. All documents referenced in Section 270000 General Provisions for Communication Systems are hereby incorporated by reference within this Section.
   1. Emphasis shall be placed on articles specifying:
      a. Optical fiber cable standards and procedures for selection and installation.

1.3 REGULATORY REQUIREMENTS

A. All Work shall conform to the requirements of NFPA 70.
   1. All Work shall conform to the requirements of all Federal, State and Local Electrical and Telecommunications Regulations.

1.4 DESCRIPTION AND GENERAL SPECIFICATIONS

A. Provide all labor, materials, tools, equipment and services required to complete the work described herein and shown on the drawings and as required to provide a fully operational optical fiber backbone system.

B. All communications optical fiber backbone cabling, other materials and appurtenances specified herein shall be UL listed, approved and suitable for the environment where installed, unless noted otherwise.

C. The drawings, which constitute a part of these specifications, indicate the general route of the pathway systems. Contractor shall verify existing field conditions and coordinate exact routing, location, distance and levels and other work of this Section with other trades prior to installation.

D. Notify the Designer or Owner’s Representative of any changes due to conflicts with other trades work, or due to any other reason other than of a minor nature prior to proceeding with work.

E. Make necessary provisions for storage of materials and equipment at the site to ensure the quality and condition of the product to be installed. Use only materials and products that are new, free of defect, and which arrive unopened and in the original container at the jobsite.

1.5 DEFINITIONS

A. Refer to Section 270000

1.6 ABBREVIATIONS AND ACRONYMS

A. See specification 270000 General Provisions for Communication Systems Section 1.11 Abbreviations and Acronyms.

1.7 SUBMITTALS

A. Submittals shall be prepared and delivered in accordance with Section 270000 General Provisions for Communication Systems and Division 0 and Division 1 in sufficient detail to show full compliance with the specification.

B. Manufacturer's Catalog Data shall be submitted for the following items at minimum:
   1. Optical fiber backbone cable.
   2. Optical fiber connectors and adapter panels.
   3. Optical fiber cable fasteners and connectors.

C. Data shall include a complete list of parts, special tools, and supplies with source of supply.

D. Provide the number of copies of submittals in the method specified in the general provisions of these specifications.

1.8 QUALITY ASSURANCE:

A. Conform to all conditions within "Quality Assurance and Workmanship" in Section 270000 General Provisions of Communications Systems.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall be new and as specified, first quality, manufacturer's current production.

B. Contractor shall provide plenum, riser, LSZH or non-plenum cable as specified herein and on drawings. Contractor shall field verify plenum/non plenum requirements prior to installation.

C. For optical fiber applications, all fiber and connectivity solutions shall meet performance specifications of ANSI/TIA 568-C.3, 598-C and 758 (water-blocked cables).
   1. Additional standards referenced for optical fiber cable and materials are ANSI X3T9.5 PMD, ATM 155 Mb/s, Fibre Channel FC-PH, GR-409-CORE, ICEA-S- 104-696, ICEA-S-83-596 and ICEA-S-87-640.

D. Contractor shall be responsible for verification of each of the above requirements prior to beginning of work. Contractor shall immediately notify Owner's Representative of any product conflicts before proceeding with work.

2.2 SINGLEMODE OPTICAL FIBER BACKBONE CABLE - UNARMORED

A. Indoor/Outdoor Riser-rated Unarmored Optical Fiber –

PART 3 - EXECUTION

3.1 GENERAL

A. Provide, connect and test all equipment and materials for the systems herein specified and shown on the drawings. All wiring shall be run in cable tray, raceway or other specified supports as specified on drawings. Each cable shall be labeled with a wrap-around label at both ends

B. Where plenum cable is specified, it is to be provided. Where the cable jacket type is specified herein or on the Drawings, the Contractor shall field verify the surrounding environmental spaces before starting the work. Contractor shall immediately notify the Owner's Representative of any discrepancies or conflicts found before proceeding with installation.

C. Wherever materials, methods or placements of materials and equipment for the communications work is provided by other Subcontractors or the Owner, it shall be the responsibility of this specialty Subcontractor to coordinate that work and assure that it is provided in such a manner as to enhance the final system operation.

D. Coordinate installation of lighting, ventilation and all other systems in the communication rooms to avoid interferences.

3.2 LAYOUT

A. Layout all work in accordance with the provisions of 270000 General Provisions for Communication Systems.

3.3 OPTICAL FIBER BACKBONE CABLE

A. All optical fiber backbone cable shall be installed in innerduct, complete from end enclosure to end enclosure or as indicated on the drawings.

B. Provide 8 m (25 feet) of slack cable in each vault or chamber when place underground. Fiber to be secured and protected within vault without coils or excessive slack except where designated. Use approved racking hardware in vaults and handholes.

C. Install optical fiber backbone cabling as indicated on the drawings. Cable shall be installed continuously without break from end-to-end unless specified otherwise or unless prior approval is permitted in writing from the Contract Authority.

D. Distances shown on drawings are for conduit paths only and do not include lengths across manholes, electrical rooms or working slack.

E. Notify Owner and A/E immediately of any damage to existing underground fiber, copper or utility cables. Contractor shall assume that the entire underground and aboveground cable plant is active and that no dead or unused cables exist.

F. Splice pigtails and install connecting components and hardware in enclosures and racks. Label per TIA-606-C.

G. Where splicing is indicated, follow the manufacturer's recommendations, utilize a high grade fusion splicer and ensure the operator is trained and qualified for the specific operation.

H. Maintain manufacturer’s specified minimum bend radius for all cable types. Cables shall not be kinked during installation.

I. The manufacturer-recommended pulling tension of the cable shall not be exceeded. Refer to manufacturer recommendations for “loaded” tension (during pulling) and “installed” tension (at rest after pulling). Installer shall use “loaded” tension specifications and shall submit pulling tension calculations to the Engineer of Record along with planned pulling method (winch, hand, or other means) prior to start of work.

J. Non-approved pulling methods are prohibited. Uses of vehicles or other machinery not generally accepted will automatically result in replacement of all cable using that method at no cost to owner and no impact to schedule.

If applicable, contractor shall refer to cable schedules, vault “butterfly drawings” and conduit schedules (where applicable) on the drawings before placement of fiber.

K. Contractor shall submit a formal cable pulling plan to the Engineer of Record for approval before start of work. The plans shall include at a minimum a detailed description of routes, splice points (if any), schedule, road closures and use of space, equipment characteristics and use (including pulling tension), and personnel.

L. All backbone cabling shall be installed in pathways as defined in ANSI/TIA-569-C Pathways and Spaces and installed in accordance with ANSI/TIA 568-C.1 and C.3, BISCI guidelines as described in the Telecommunications Distribution Methods Manual, the NEC and state and local codes.

M. Secure all optical fiber in cable trays or basket trays using Velcro-style cable ties at minimum 8 foot intervals on horizontal runs and at 2 foot intervals in vertical runs.

N. All cable installation shall not exceed 40% of total fill capacity of conduits or innerducts, or more than 50% of total fill capacity of cable trays.

O. All cabling installed in vaults or other underground enclosures shall be racked and fastened neatly to sides of vault using approved corrosion-resistant fitting and fasteners. Cables shall avoid contact with vault floor or where water or mud might accumulate.

P. Route all cabling to the locations indicated on Plans. Provide 30 foot loop, coiled and stored, at each end within 25 feet of optical fiber cable termination point, and at each exterior vault location.

Q. Immediately after cable placement, a permanent identification tag as indicated shall be attached to visible cable sections. Cables shall be checked to ensure that the markings are intact.

R. Cables and equipment shall be supported and secured. Where the specific method of support is not indicated, supports and fasteners shall be used to secure cables and equipment in position.

S. Where installed in corrosive, wet or damp environments, metallic supports and fasteners shall have a corrosion resistant finish. All cables shall be routed along the interior sides of manholes.

3.4 GROUNDING

A. In outside plant applications or where the optical fiber cable contains metallic components including armor or shielding, and where cable extends outside of the cone of protection for any structure; ground all metallic elements in accordance with Section

B. 27 05 26 Grounding and Bonding for Communications Systems.

3.5 LABELING OPTICAL FIBER BACKBONE CABLES

A. All work shall be labeled according to ANSI/TIA/EIA 606, and color-coded according to BICSI Standards.

B. Mark and tag fiber-optic cables in each vault with an Owner-provided sheath number. Include far end location and distance on each label.

3.6 TESTING OF OPTICAL FIBER BACKBONE CABLING

A. Telecommunications System test reports shall be submitted to and approved by the Contracting Agency. The test reports shall certify that the Telecommunications Distribution System is complete, passes all test criteria, is fully operational, and that all work has been witnessed as specified.

B. Test all backbone cabling in accordance with ANSI/TIA 568-C.1, ANSI/TIA 568-C.3 and revised errata.

3.7 OPERATING AND MAINTENANCE MANUALS

A. Prepare and submit operating and maintenance manuals in accordance with the provisions of Section 270000 General Provisions for Communication Systems.

END OF SECTION 271323

SECTION 271513

COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Installation and termination of copper horizontal cabling.

1.2 REFERENCES

A. All documents referenced in Section 270000 General Provisions for Communication Systems are hereby incorporated by reference within this Section.
   1. Emphasis shall be placed on articles specifying horizontal copper Category-rated cabling and its installation methods and procedures.

1.3 REGULATORY REQUIREMENTS

A. All Work shall conform to the requirements of NFPA 70.

B. All Work shall conform to the requirements of all Federal, State and Local Electrical and Telecommunications Regulations.

1.4 DESCRIPTION AND GENERAL SPECIFICATIONS

A. Provide all labor, materials, tools, equipment and services required to complete the work described herein and shown on the drawings and as required to provide a fully operational system.

B. All installed horizontal cable shall be UL listed, approved and suitable for the environment where installed.

C. Notify the Designer or Owner’s Representative of any changes due to conflicts with other trades work, or due to any other reason other than of a minor nature prior to proceeding with work.

D. Make necessary provisions for storage of materials and equipment at the site to ensure the quality and condition of the product to be installed. Use only materials and products that are new, free of defect, and which arrive unopened and in the original container at the jobsite.

1.5 DEFINITIONS

A. The term "horizontal cable" means the cabling between and including the telecommunications outlet/connector and the horizontal cross-connect.
   1. For Wireless LAN the cross-connect exists at the interface of the AP and SMA-N adapter cable.

1.6 ABBREVIATIONS AND ACRONYMS

A. See specification 270000 General Provisions for Communication Systems Section 1.11 Abbreviations and Acronyms.

1.7 SUBMITTALS

A. Submittals shall be prepared and delivered in accordance with Division 01 and Section 270000 General Provisions for Communication Systems in sufficient detail to show full compliance with the specification.

B. Manufacturer's Catalog Data shall be submitted for the following items at minimum:
   1. Horizontal copper cable
   2. Horizontal cable fasteners and innerduct.

C. Data shall include a complete list of parts, special tools, and supplies with source of supply.

D. Provide the number of copies of submittals in the method specified in the general provisions of these specifications.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall be new and as specified, first quality, manufacturer's current production.

B. Contractor shall provide plenum, riser or non-plenum cable as specified herein and on drawings. Contractor shall field verify plenum/non plenum requirements prior to installation.

C. All copper cable designated as Category 3, 5, 5e, 6 and 6A shall meet all material and performance specifications defined in ANSI/TIA 568-C.2 and the NEC.

D. For copper cabling specified as Category 5 or above ALL connectivity hardware shall be compatible with the selected horizontal cable, contain the same Category rating, and meet impedance-matching performance requirements defined in ANSI/TIA 568-C.2 and by the manufacturer.

E. For copper voice-grade applications, connectivity hardware shall be compatible with the connected cable and meet performance requirements of Category 3, as defined in ANSI/TIA 568-C.2.

F. Contractor shall be responsible for verification of each of the above requirements prior to beginning of work. Contractor shall immediately notify Owner's Representative of any product conflicts before proceeding with work.

2.2 HORIZONTAL COPPER CABLE AND TERNMINATIONS

A. Cat 6 Cable and Terminations
   1. Type: UTP (Unshielded Twisted-Pair)
   2. Category Rating: Cat 6, rated for a minimum bandwidth of 1Gbps
   3. Pairs: 4-pair, #24 AWG solid
   4. Color: Blue (Office), Gray (Apartments) and Orange (CCTV Cameras)
   5. Jacket rating: To meet code.
   6. Approved Manufacturer: Panduit for all cable, patch panels, jacks and faceplates.

2.3 UNSPECIFIED EQUIPMENT AND MATERIAL

A. Any item of equipment or material not specifically addressed on the drawings or in this document and required to provide a complete and functional cable and telecommunication system installation shall be provided in a level of quality consistent with other specified items.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide, connect and test all equipment and materials for the systems herein specified and shown on the drawings. All wiring shall be run in cable tray, raceway or other specified supports as indicated on drawings. Each cable shall be labeled with a wrap-around label at both ends

B. Where plenum cable is specified, it is to be provided. Where the cable jacket type is specified herein or on the Drawings, the Contractor shall field verify the surrounding environmental spaces before starting the work. Contractor shall immediately notify the Owner's Representative of any discrepancies or conflicts found before proceeding with installation.

C. Wherever materials, methods or placements of materials and equipment for the communications work is provided by other Subcontractors or the Owner, it shall be the responsibility of the Contractor to coordinate that work and assure that it is provided in such a manner as to enhance the final system operation.

D. Coordinate installation of lighting, ventilation and all other systems in the communication rooms to avoid interferences.

E. All cable shall be installed utilizing TIA and BISCI best practices and in accordance with the manufacturers recommended practices.

3.2 LAYOUT

A. Layout all work in accordance with the provisions of 270000 General Provisions for Communication Systems.

B. Maximum height for termination and patching enclosures or patch panel ports shall be 7'0"; minimum height shall be 28". Cables shall be installed and supported in a workmanlike fashion.

3.3 HORIZONTAL CABLE INSTALLATION

A. All cabling shall be installed in pathways as defined in the drawings using a dedicated 1" innerduct for each faceplate.

B. Layout cable runs in advance to determine routing of innerduct to minimize bends between the outlet and chase.

C. Follow cable manufacturer's specification regarding handling methods, retaining/support methods, bending radius and maximum pulling tension limitations.

D. Any cables that are damaged or suffer sheath micro-bending during installation shall be replaced without additional cost to the owner.

E. Office workstation and apartment cabling shall consist of (2) Category 6 copper cables per faceplate unless otherwise indicated. These cables shall be routed to the MDF as shown on the drawings.

F. Outlets for wall-mounted or other "telephone only" installations shall consist of (1) Category 6 cable unless otherwise indicated.

G. All horizontal cables shall be supported in a dedicated 1" innerduct (one per faceplate) to maximize the ability to add or replace cables at a later date as standard communications pathways are not available.

H. All communication cabling, including horizontal cabling shall be routed parallel to or perpendicular to building lines to minimize bends.

I. All cables shall be routed to minimize EMI and RFI interference. Maintain minimum distance of thirty-six (36) inches from inductive and EMF electrical sources such as electronic or magnetic lighting ballasts and motors.

J. Install all horizontal cabling without break from the workstation outlet and jacks to the termination hardware in the assigned Telecommunication Room. Provide a 6-foot service loop at the outlet end.

K. Do not cut or splice cables.

L. Remove excess length from cable ties and in a manner that leaves no sharp edges.

M. Use Velcro straps to bind cable bundles within Telecommunications Rooms or Spaces. Provide straps at one foot intervals. Do not bind cables tightly together with straps. Straps shall slip loosely around cable. Straps shall not deform the cable insulation when tightened.

N. Provide and install all necessary materials, hardware, tools, and equipment to install and terminate every cable at each telecommunication outlets/connectors and patch panels and wiring blocks.

O. Install cables in consistent consecutive order. Arrangement of cables on patch panels and wiring blocks shall be in ascending order of outlet numbers.

P. During cable pulls, cable laying on floors or other areas shall be protected from damage and foot and vehicle traffic.

3.4 GROUNDING

A. Provide protector frames and protectors at building entrances in accordance with Section 270526, unless noted otherwise on Drawings for all copper cabling.

3.5 LABELING OF HORIZONTAL COPPER CABLING

A. See cable schedule for faceplate Labeling.

B. All work shall be labeled according to ANSI/TIA/EIA 606.

3.6 TESTING OF HORIZONTAL COPPER CABLING

A. Telecommunications System test reports shall be submitted to and approved by Everett Housing Authority. The test reports shall certify that the Telecommunications Distribution System is complete, passes all test criteria, is fully operational, and that all work has been witnessed as specified.

B. Test all horizontal copper cabling in accordance with TIA 568-C.

3.7 RECORD DRAWINGS

A. Upon completion of the project, Contractor shall submit red-lined drawings to the Engineer of Record indicating each outlet identification number and showing installed locations of each horizontal outlet including those in offices, apartments and for IP CCTV.

B. After final Record Drawings are completed and issued by the Engineer, Contractor shall:
   1. Prepare and submit to the Engineer and Owner a “room-to-jack” database in excel format showing outlet identification numbers and associated room numbers. Also include this spreadsheet in O&M submittals.

END OF SECTION 271513

SECTION 282300

VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Contractor shall provide all materials, hardware, software, fabrication, coordination and installation, programming, testing, documentation, and training in conformity with manufacturers' documentation, the specifications contained herein, all applicable Codes and authorities having jurisdiction for the implementation of a complete Video Surveillance System (VSS). Refer to Scope of Work section within this specification for further details.

B. Contractor shall be responsible for coordination of all VSS system related installation issues with any and all stakeholders, Everett Housing Authority (OWNER) IT Department, and other trades. This includes programming of all software and hardware, connections/interfaces. Coordination of conduit/pathways, and power requirements for security devices directly with electrical contractor when necessary to complete installation. Refer to Scope of Work section within this specification for further details.

1.2 PROJECT SCOPE

A. Contractor shall be responsible for fully implementing the functions described in the specifications and shown on the Design Drawings and Specification Documents, which may not show or list every item required or to be provided. When an item not shown or listed is clearly necessary for proper installation and operation of equipment or the system(s), Contractor shall provide this equipment, components, or software at no additional cost to the Owner.

B. Provide and submit all required documentation as a single submission at the beginning of the project as outlined in the Submittals section.

C. A Complete turnkey Video Surveillance system is defined as all fiber optic switches, edge switches, SFP/GBIC modules, fiber optic patch cords, Category 6 patch cords for connection to the dedicated security network provided under this specification section, all software, VMS application, all licenses for the VMS and cameras, recording storage servers/appliances, workstation(s) with dual 24" monitors, cameras, camera ceiling installation kits, camera outdoor housing assemblies, encoders, power supplies, etc., as well as all cabling/wiring not provided by others as referenced herein, provide all programming and make all adjustments, system test, checkout and commissioning, provide all Shop Drawings and Data Sheet Submittals, Close Out Submittals, including Test Reports, Operation and Maintenance Manuals, Training Classes and materials, As built or Record Drawings, and certify (submit Warranty Certificate) the entire integrated access control/video surveillance system solution needed to achieve a complete and functional system, as basis of the Contract Price.

D. The (VSS) shall be a complete system provided with Remote Viewing and Mobile Device viewing capabilities as part of the video management system for this project.

E. The system design includes new IT Rack mounted equipment including a mid-tower workstation, desktop KVM switch, slide out/lift up 17" LCD 1080p display with keyboard, network switches and video recording server with accessories, video, control/USB cabling, interconnect and 2U rack shelf.

F. Contractor shall coordinate all his work and work in harmony with other trades on the project as well as with A/E personnel and contractors performing work under a separate contract where all work is contributing to the overall project. Cooperate fully with the Architect or his agents so work may be carried out smoothly, without interfering with or delaying work under this contract or work by Architect.

This would include timely submission of documents and/or notices of impending scheduled events or milestones where others are required to attend or participate in reviews, site walks, testing, commissioning and demonstration for Final Acceptance with the A/E personnel.

1.3 REFERENCES

A. Each agency's relative codes, standards, and recommended practices apply to the Access Control System and its components as specified herein.

B. Published specifications, standards, tests, codes, or recommended standards of trade, industry, or governmental organizations apply to work in these Sections, including:
   1. ADA - Americans with Disabilities Act
   2. ASCII - American Standard Code for Information Interchange
   3. ASTM - American Society for Testing and Materials
   4. EIA – Electronic Industry Association
   5. NEMA - National Electrical Manufacturers' Association
   6. NFPA - National Fire Protection Association
   7. NEC - National Electrical Code
   8. UL - Underwriters Laboratories, Inc.
   9. ASIS – American Society for Industrial Security
   10. FCC – Federal Communications Commission
   11. OSHA – Occupational Safety and Health Administration
   12. IEEE – Institute of Electrical and Electronic Engineers
   13. ANSI – American National Standards Institute
   14. State and Local Fire Marshal

C. Electronic devices radiating "RE" energy shall comply with Federal Communication Commission regulations, particularly Part 15, and shall meet minimum Class "B" requirements. Provide FCC certificate numbers indicating that the FCC has approved products.

D. Where any of the above standards or codes differs with the contract documents and specification, the more stringent requirements shall take precedence. Any cost necessary to meet any AHJ requirements shall be included in Contractor's price.

1.4 QUALITY ASSURANCE

A. Contractor and any Subcontractors shall be responsible for and familiar with all city, county, state, and federal codes, rules, ordinance, and regulations of the AHJ and their interpretations, which are in effect for these Premises.

B. The latest issue of all recognized codes, standards, and recommended practices of the following agencies in effect on the date of award of a contract shall form a part of this specification.

C. A nationally recognized test laboratory shall list all equipment supplied where applicable.

D. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

E. All items of a given type shall be the products of the same manufacturer.

F. All items shall be new and of the latest technology and version-level; no discontinued models or products are acceptable.

G. No Beta products will be accepted.

H. The manufacturer, or their Authorized Representative, shall confirm that within 100 miles of the project site there is an established agency which:
   1. Provides a full-Service Operation and stocks a full complement of replacement parts.

2. Offers service during normal working hours as well as emergency service on all equipment to be furnished.
3. Will supply parts and service without delay and at reasonable cost.

I. Contractor shall be a factory authorized representative of Milestone Systems, licensed to sell, install, and maintain all system, subsystems, components, and software required in the United States, and shall present a copy of their certificate designating them as a factory authorized distributor/installer.

J. Contractor shall have at least five (5) years' experience designing, selling, installing and maintaining the VMS/VSS equipment being bid, and shall possess all applicable Contractor licenses.

K. Skilled technicians are to perform all installation, commissioning, programming and testing and are, at a minimum, to be factory trained and certified to work with the video surveillance system.

L. Contractor shall employ a competent Foreman to be in responsible charge of the Work. Foreman shall be on the project site daily during the execution of the Work.

M. Contractor's Foreman shall be a regular employee, principle, or officer of Contractor, who is thoroughly experienced in projects of a similar size and type. Contractor shall not use contract employees or Subcontractors as Foremen.

N. All software provided shall be the latest version available by the manufacturer upon final acceptance of the system. This includes Microsoft products contained as part of the system. All of the latest updates and patches shall be installed at the time of acceptance.

O. Contractor shall make application for and obtain any and all permits required by federal, state, county, city, or other authority having jurisdiction over the work.

1.5 SUBMITTALS

A. Provide the following Data Sheets, NVR Storage Calculations and Shop Drawing package documentation as a complete submission to OWNER at the start of the project.
1. Provide a complete Bill of Materials with quantities of equipment supplied.
2. Data Sheet submittals indicating manufacturers name, model number, and a full description of the component and UL Listing for all equipment supplied.
   a. Provide a Data Sheet for every item listed in the Bill of Material.
   b. Indicate or high light all model numbers of equipment to be reviewed prior to submission for approval.
3. Provide NVR Storage Calculations – NVR shall record only alarm events. To size the NVR hard disk size, submit a report or screen shot of the camera or NVR manufacturer's website for video storage calculation. Motion detected alarm events will be recorded at 30 frames per second with 2 minutes pre- and post-alarm event and saved as a "Clip" to the NVR. Alarm clips older than 30 days can be overwritten or programmed to be deleted to make room for newer alarm clips. Camera recording stream profile for all camera/NVR storage calculations is based on;
   a. All cameras indicated on the Design Drawings.
   b. 30 days' retention.
   c. 30% motion detection.
   d. Native resolution of the given camera.
   e. 30 frames per second.
   f. Variable bit rate.
   g. H.264 compression.
   h. Plus 20% spare capacity.
4. Shop Drawing package shall be submitted and is the foundation of the As Built drawing package, and shall include the following details;
   a. Provide dimensioned elevations and details for every console, rack, and fabricated equipment being supplied under this section.

b. Device location Floor/Site Plans with each device having a unique ID.
c. Block Riser/Network Diagram of all devices in the system.
d. Device Schedule of all cameras in the project.
e. Rack Elevations for rack mounted equipment at the Head End to verify Rackspace requirements.
f. Mounting Details for all mounted components, cameras, etc.

5. Partial or “Typical” drawings will not be accepted.
   a. All drawings shall be done in CAD drafting software.
   b. Duplication of Design/Bid Drawings submitted as a Shop Drawing package shall be rejected.
6. To ensure compatibility with an existing legacy network, and a project is an extension of an existing legacy system, Contractor shall provide a list in electronic format/spreadsheet of all new devices with unique device ID’s and mac addresses that require connection to the existing campus network. This information will be merged with existing equipment information and become an approved Table of IP addresses for Contractor to use for his new equipment IP addresses.
7. Training Program documentation, including name and qualifications of trainer(s), schedule of training, curricula, and written training materials. As built drawings shall be available as part of the Training program.
8. Service information, including address of nearest representative. Provide written approval from each manufacturer affirming that Contractor is certified and approved for systems installation and service for all systems in this Section.
9. Provide Maintenance Procedures to include the following information;
   a. Provide full procedures for all tasks that must be performed to ensure the warranty remains intact.

B. Provide the following items subsequent to the Shop Drawings and Data Sheet submission in electronic format (.pdf);
   1. Provide all Test Reports as indicated in Section 3.3 TESTS AND REPORTS when completed in a timely manner for approval.
   2. Provide (2) complete hardcopy plus (1) electronic copy (.pdf) of Operation and Maintenance manuals for all approved equipment installed. This O&M manual shall be available for Training classes and be part of the Training materials. This document manual must be approved and available for use in Training and Final Acceptance.
   3. Provide all documentation referenced in under the Warranty section referenced within this specification and provide Warranty Certificate in electronic copy (.pdf) indicating customer name, site address, system under warranty, date warranty begins and ends, service department contact information and manufacturer contact information.

C. Submittals must be complete, as in all items listed above under Shop Drawings and Data Sheets shall be submitted at one time together as a package. Incomplete or partial Shop Drawings and Data Sheets submittals shall be rejected.

D. The Security Consultant and OWNER reserve the right to reject any submittals determined to be incomplete.

E. Operation and Maintenance manual shall be submitted prior to demonstration for Final Acceptance and Training.

1.6 SUBSTITUTIONS

A. All materials and equipment shall conform to these specifications. No substitute equipment or materials may be used unless accepted in advance in writing by OWNER and the Security Consultant.

B. Manufacturers listed as acceptable are normally engaged in the type of work specified. The listing of equipment part numbers or particular types of systems by specific manufacturers is to establish the performance, quality, and parameters of the equipment and material specified.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All equipment provided shall be new, not used, and shall be shipped in original packages to prevent damage or entry of foreign matter. All handling shall be in accordance with manufacturers' recommendations. Protective covering shall be provided by Contractor during construction.

B. Components to be stored for future use shall be kept inside a well-ventilated space protected from weather, damage, breakage, and scoring of finishes. Contractor shall replace, at no expense to OWNER, equipment and material damaged during storage and installation as directed by OWNER.

C. Products delivered to the job site in racks and consoles shall be protected from dust, dirt and foreign matter. All racks and consoles shall be protected from dents, bumps and scratching. Contractor shall replace all parts damaged in shipping or in storage with new at no cost to the Owner.

D. Used components are not permitted for installation at the Premises.

1.8 WARRANTY

A. Contractor warrants that all Work furnished (material and labor) under this Contract will be of good quality, free from faults and defects, and in conformance with the Project Drawings and Specifications.

B. Contractor shall provide a parts and labor guarantee on all Work. Unless otherwise specified herein, Contractor's guarantee shall be for a period of one (1) year from date of Acceptance, except where any specific guarantees from a supplier or equipment manufacturer extends for a longer time.

C. Contractor's guarantee shall cover all costs associated with troubleshooting, repair, and replacement of defective Work, including costs of labor, transportation, lodging, materials, and equipment.

D. Guarantee shall not cover any damage to material or equipment caused by accident, misuse, unauthorized modification or repair by the Owners, civil unrest, or acts of god.

E. Provide a Certificate of Warranty to include Site name, date Warranty begin and ends, Service Provider contact information, complete street address and phone number. Contractor and manufacturer(s) shall warranty all equipment, materials and installation labor for a minimum of one (1) year from the date of written notification of Acceptance by OWNER.

F. During the Warranty Period, upon notification of a problem by OWNER, Contractor shall ensure that a competent and qualified field service technician arrives on site to correct the problem within 24 hours of notification. If a problem can be corrected remotely to OWNER'S's reasonable satisfaction, the on-site arrival time commitment shall be waived.

G. At least sixty (60) calendar days prior to expiration of Warranty, Contractor shall provide OWNER with post-Warranty maintenance contract proposals. The terms and condition of any such post-Warranty program shall be consistent with those offered to the provider's most favored customer(s).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. System specifications, functionality, system capabilities and products outlined in this specification are based on the following;
   1. VMS shall be XProtect Express+, by Milestone Systems, Inc., 8905 SW Nimbus Avenue, Suite 400, Beaverton, OR 97008, USA, Telephone: +1 503 350 1100, Toll-free telephone: +1 877 350 1101, Fax: +1 503 350 1199.
   2. Any additional features listed beyond the XProtect Express+ capabilities are to be disregarded and only features listed by Milestone for their standard XProtect Express+ product are required in this specification.
   3. Acceptable IP camera manufacturers include AXIS, Sony, or Arecont Vision.
   4. Network Video Recorder shall be Milestone Husky X2,

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Systems shall be complete and operational in all respects.

B. Contractor shall furnish and install all equipment necessary to build the Integrated Security System as referenced herein.

C. All wall, floor, and ceiling penetrations, regardless of fire rating, must be properly sleeved with conduit and properly sealed using approved fire stopping materials and sealants, according to OWNER standards.

D. All security equipment, junction boxes, terminal cans, etc. installed in public accessible areas shall be installed utilizing tamper proof mounting hardware. Contractor shall provide a minimum of 2 driver bits or hand tools for each type and size of security fastener provided.

E. Contractor shall provide seismic restraint for all equipment, including equipment racks, consoles, etc.

3.2 PROGRAMMING

A. Contractor shall provide initial programming for all applicable systems. Contractor programming shall include, but not be limited to:
   1. English-language description of each alarm location.
   2. Programming of the head-end equipment.
   3. Programming of Video Management Software.

B. Submit to OWNER for the review of the proposed programming, including device names and descriptions, timings, sequence of operations, etc.

C. Upon OWNER'S's request, Contractor shall reprogram each system one time during the Warranty Period at no additional cost. At no additional charge, Contractor shall update the system software to the most recent version available at the time of the reprogram.

3.3 TESTS AND REPORTS

A. Contractor shall perform system tests using personnel who have attended a manufacturer's training school for installation and testing of the systems as described herein. Contractor shall perform testing with the test instruments as specified/directed by the manufacturer. Testing by means other than the manufacturer's procedures will not be acceptable unless agreed to in advance in writing by OWNER, Security Consultant and the equipment manufacturer.

B. Upon completion of the installation of the Security Systems, Contractor shall submit written reports including, but not limited to, the following information:
   1. A complete list of all equipment installed, including serial numbers of major components.
   2. Certification that all equipment is properly installed, programmed, functional, 100% operational, and in conformance with contract Specifications and Drawings.
   3. Test reports of all connected devices and equipment, including IP addresses, device Id's and test results indicating pass/fail of device operation.
   4. Test technician's name, company and date of test.

C. Following review of the test report(s) by OWNER, Contractor shall perform a test of Security System equipment in the presence of OWNER and the Consultant. Test(s) shall include performance tests of all equipment and material required by the contract. Contractor shall be responsible for all additional costs to OWNER if retesting is required. At a minimum, perform tests to demonstrate that:
   1. All systems are free from grounding problems and open circuits.
   2. Systems operate properly on battery backup.
   3. All software functions properly as specified, and all equipment is fully programmed.
   4. Contractor shall disable all unused ports of all switches deployed in the dedicated security network. Provide and submit a written Test Report that indicates all the unused ports are disabled. This test report shall be available at time of demonstration of Final Acceptance.

D. Sixty days prior to expiration of Warranty, Contractor shall retest all systems as described herein, and submit a test report of findings. All items covered by Warranty shall be corrected immediately. The Warranty shall remain in effect until Contractor corrects 100% of defective items.

3.4 COMMISSIONING

A. After all Work is completed, and prior to requesting the Acceptance test, Contractor shall conduct a final inspection, and pre-test all equipment and system features. Contractor shall correct any deficiencies discovered as the result of the inspection and pre-test.

B. Contractor shall submit a request for the Acceptance test in writing to the Security Consultant no less than fourteen days prior to the requested test date. The request for Acceptance test shall be accompanied by a certification from Contractor that all Work is complete and has been pre-tested, and that all corrections have been made.

C. During Acceptance test, Contractor shall demonstrate all equipment and system features to Security Consultant and an Owner's Representative. Contractor shall remove covers, open wiring connections, operate equipment, and perform other reasonable work as requested by Security Consultant and the Owner's Representative.

D. Any portions of the Work found to be deficient or not in compliance with the Project Drawing and Specifications will be rejected. The Security Consultant will prepare a list of any such deficiencies observed during the Acceptance test. Contractor shall promptly correct all deficiencies. Upon correction of deficiencies, Contractor shall submit a request in writing to the Security Consultant for another Acceptance Test.

E. If, at the conclusion of the Acceptance Test, all Work is found to be acceptable and in compliance with the Project Drawings and Specifications, The Security Consultant will issue a letter of Acceptance to Contractor and the Owner's Representative.

3.5 AS-BUILT DRAWINGS

A. Contractor shall maintain a complete set of OWNER Approved Shop Drawings on-site as the work on the Access Control System is being completed. As work is installed, Contractor shall carefully draw on prints the correct location of work including all critical dimensions.

B. Upon completion of the project, Contractor shall transfer hand-drawn information to CAD Drawings, updated CAD disks, and submit to OWNER for review. No hand-drawn as-built drawings shall be accepted.

C. Contractor shall provide four (4) sets of As-built Drawings, plus one (1) set of CAD disks, to OWNER. One (1) additional complete set shall remain on the job site in folders secured on the wall adjacent to the control panels.

3.6 TRAINING AND OPERATION/MAINTENANCE MANUALS

A. Contractor shall provide a minimum of four (4) copies of Operation and Maintenance manuals for all equipment furnished under the Security Systems sub-sections. These manuals are to be available during training.

B. The Operation and Maintenance manuals shall include the following information and full procedures for;
   1. Database back-ups.
   2. Server/workstation hard drive maintenance, such as defrag, drive and RAM memory replacement, etc.
   3. Maintaining physical and software firewalls.
   4. Upgrading any software used in the system.
   5. Testing battery condition on all field panels for adequate back-up time.
   6. Any other tasks that must be performed to ensure the warranty remains intact.

C. Provide a minimum of eight (8) hours of scheduled training for the equipment furnished under this Section, including programming, operation, service, and maintenance.

D. Training shall be by engineers or technicians highly skilled in the systems and certified by manufacturer as qualified to train in the particular systems.

E. Training shall be conducted at dates and times directed by OWNER'S's representative. Training shall be provided for all security staff personnel and system end-users.

F. OWNER, prior to release of retention compensation, shall require verification of completion of training.

3.7 IT REQUIREMENTS

A. Contractor shall coordinate with the IT department (IT) for all network and telecom connections to keep within the level and consistency of workmanship quality, materials selection and installation methods for all work performed in any Telecommunications Room (TR).

B. Security Contractor shall request an IP address table from the IT department (IT) for all devices requiring an IP address. The address table must be approved prior to deploying and programming devices and a Report submitted for review at demonstration of Final Acceptance.

C. Refer to Section 3.03 Tests and Reports for further information.

END OF SECTION 282300

SECTION 310000

EARTHWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies earthwork, which consists of excavation, filling, grading, and excess material control.

B. Related Sections:

1. 015713 – Temporary Erosion and Sediment Controls

2. 311100 – Clearing and Grubbing

1.2 STANDARD SPECIFICATIONS

A. This section incorporates by reference the latest revisions of the following documents. They are part of this section insofar as specified and modified herein. In case of conflict between the requirements of this section and the listed documents, the requirements of this section shall prevail.

Reference	Title
WSDOT	Standard Specifications for Road Bridge and Municipal Construction 2020.
COE	Design and Construction Standards and Specifications for Development, Public Works Department, January 2019.

B. The Contractor shall have one copy of the Standard Specifications at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections and the measurement and payment sections do not apply to this document.

1.3 QUALITY ASSURANCE

A. Soil Testing

1. The Owner will engage a Geotechnical Consultant to test soil materials proposed for use in the work and for quality control testing during excavation and fill operations.

2. The Contractor shall furnish samples of materials to the Geotechnical Consultant fourteen (14) Working Days before their anticipated use.

3. Under this contract, smooth out areas for density tests and otherwise facilitate testing work as directed.

B. Shoring Systems

1. Pre-engineered systems, cleared labeled as such, may be used.

1.4 EXISTING CONDITIONS

A. Site Information: GeoEngineers investigated subsurface conditions. Their report “Geotechnical Engineering Services for Everett Housing Authority Baker Heights Redevelopment, dated October 30, 2019” and any other available data may be reviewed by contacting the Owner.

B. Native soils contain significant fines content (silt/clay) and are highly sensitive and susceptible to moisture and equipment loads. These site soils are very moisture sensitive and can be difficult to compact during periods of wet weather or if impacted by groundwater seepage. Reuse of native soils, as structural fill shall only occur during periods of extended dry weather. Native soils shall be exported offsite during wet weather or if unable to meet moisture and compaction requirements.

PART 2 - PRODUCTS

2.1 STRUCTURAL FILL

A. Imported Soils: Imported gravel borrow shall be used during wet weather or in wet conditions (October through May) as described in WSDOT section 9-03.14(1) with the additional restriction that the fines content be limited to no more than 5% and capable of achieving required compaction. During dry weather (June through September) imported structural fill shall meet the criteria for common borrow per section 9-03.14(3) of the WSDOT Standard Specifications 2020, provided the contractor can achieve the required compaction criteria and moisture conditioning requirements for compaction.

B. Native Soils: Onsite glacial till soils may be used for structural fill during dry conditions (June through September), if free of trash and debris and if the earthwork contractor can properly moisture condition the soil to achieve the required compaction for its intended use. Do not use native soils for structural fill during wet weather construction or if unable to meet moisture and compaction requirements.

2.2 NONSTRUCTURAL FILL

A. Nonstructural fill shall be native or imported well-graded granular material free of organics and debris. Maximum particle size 4 inches and no more than 30 percent fines (material passing No. 200 sieve). Material shall be capable of being compacted as specified under the weather conditions prevailing at time of construction. Native soils are moisture sensitive and may not be capable of compaction under wet weather conditions.

2.3 GRAVEL BACKFILL FOR PIPE ZONE BEDDING

A. Gravel backfill for pipe zone bedding shall be the same as Crushed Surfacing Base Course (CSBC) and conform to Section 9-03.9(3) of the WSDOT Standard Specifications. Refer to the City of Everett Standard Drawing 615.

2.4 CSBC

A. Crushed Surfacing Base Course shall conform to Section 9-03.9(3) of the WSDOT Standard Specifications.

2.5 CSTC

A. Crushed Surfacing Top Course (CSTC) shall conform to Section 9-03.9(3) of the WSDOT Standard Specifications.

2.6 GRAVEL BORROW

A. Gravel Borrow shall meet the requirements of Imported Soils for Structural Fill, Section 2.1.A. above.

2.7 SAND

A. Sand shall conform to Section 9-03.13 of the WSDOT Standard Specifications.

2.8 GRAVEL BACKFILL FOR WALLS

A. Gravel backfill for walls shall conform to Section 9-03.12(2) of the WSDOT Standard Specifications.

2.9 GRAVEL BACKFILL FOR DRAINS

A. Gravel backfill for drains shall conform to Section 9-03.12(4) of the WSDOT Standard Specifications.

2.10 QUARRY SPALLS

A. Quarry Spalls: Erosion protection for rock pads and outfall protection shall conform to WSDOT Section 9-13.6 and shall consist of crushed or shot rock materials free from wood, bark or other extraneous material.

B. Quarry spalls shall be crushed quarry rock. Spalls shall be hard, sound and unweathered. Quarry spalls shall meet the following gradation requirements:

Sieve Size	Percent Passing
6-inch	100
3-inch	40 max.
3/4-inch	10 max.

2.11 RIP RAP

A. Rip Rap: Shall conform to WSDOT Section 8-15 and shall consist of broken stone, free from segregation, seams, cracks and other defects tending to destroy its resistance to weather. Do not use recycled concrete rubble for Rip Rap applications.

B. Rip Rap: Sediment trap discharge protection, rock lining, and emergency overflow spillways shall conform to the City of Everett Stormwater Management Manual Table 4.4.1.A Channel Protection “Rock Lining”. Rock lining shall consist of broken stone or shot rock free from wood, bard, or other extraneous material.

2.12 CONSTRUCTION ENTRANCES

A. Use Permeable Ballast for construction entrances per City of Everett Standard Plans. Permeable Ballast shall conform to the requirements of WSDOT Standard Specifications Section 9-03.9(2).

2.13 CONTROLLED DENSITY FILL (CDF)

A. CDF shall have a minimum compressive strength of 200 psi and conform to section 2-09.3(1)E of the WSDOT Standard Specifications.

2.14 CAPILLARY BREAK

A. Capillary break consist of 1-inch minus clean crushed gravel with negligible sand and silt conforming to WSDOT Standard Specifications Section 9-03.1(4)C, Grading No. 67.

2.15 CONSTRUCTION GEOSYNTHETIC (GEOTEXTILE)

A. Geotextile “Filter Fabric” shall be per WSDOT Section 9-33. The type of Geotextile used shall be specific to its use on the project and shown on the drawings and shall have the properties as listed in WSDOT Section 9-33 CONSTRUCTION GEOSYNTHETIC.

1. Geotextile for Filter Fabric Fencing shall be a woven polypropylene monofilament yarn. The fabric shall be inert to biological degradation, and shall be resistant to alkalines and acids found in soils. The base plastic shall contain stabilizers and inhibiters to make the fabric resistant to ultraviolet radiation conforming to WSDOT Section 9.33.2(1) Table 6: ”Geotextile for temporary silt fence”.

2. Geotextile for Sediment traps, catch basin protection and permanent erosion control shall be per WSDOT Section 9-33.2(1) Table 4: “Geotextile for permanent erosion control and ditch lining”.

3. Geotextile for Construction Entrances shall be per WSDOT Section 9-33.2(1) Table 3: “Geotextile for Soil Stabilization”.

4. Geotextile for Perforated Drains shall be per WSDOT Section 9-33.2(1) Table 2: “Geotextile for underground drainage and filtration properties” Class A.

5. Geosynthetic Properties for Walls and Reinforced Slopes shall be per WSDOT 9-33.2(2) Table 7.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Owner's Representative. Unauthorized excavation, as well as remedial work directed by the Owner's Representative, shall be at no change in contract amount.

1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation with CDF or lean mix concrete. The bottom width of the excavation shall be defined by a line extending downward and out from the outer edge of the footing at an angle of 1H:1V.

2. Elsewhere, backfill and compact unauthorized excavations with structural fill as specified herein.

B. Overexcavation: In certain areas where soft spots occur in the subgrade, achieve satisfactory sub-grade by overexcavation and replacement with structural fill material or lean mix concrete.

1. Location and extent of soft spot areas to be verified by Owner's Geotechnical Consultant in the field.

C. Stability of Excavations: Slope the sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

D. Shoring and Bracing: Provide shoring and bracing to comply with local codes and authorities having jurisdiction. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of the time period excavations will be open. Carry down shoring and bracing as the excavation progresses.

E. Dewatering: Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines and other dewatering system components necessary to convey water away from excavations.

2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits for each structure to convey water. Do not use trench excavations as temporary drainage ditches.

F. Material Storage: Stockpile excavated materials as required. Place, grade, shape and cover stockpiles for proper drainage and to prevent accumulation of excess moisture.

1. Locate and retain soil materials away from edge of excavations.

2. Dispose of excess soil material and waste materials legally off-site.

G. Excavation for Buildings and Retaining Walls

1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10-foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and inspection.

2. In excavating for footings and foundations, take care not to disturb the bottom of the excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive concrete. Compact base to the density required and allow testing of compaction prior to constructing concrete forms.

3. Place footings on native soils, or properly compacted fill material. Where existing soft materials are encountered below footings, overexcavate as required by the Owner's Geotechnical Consultant or until dense native soil is encountered and backfill with lean concrete. The minimum lateral limits of the overexcavation and lean concrete backfill beneath footings shall be defined by a line extending downward and out from the outer edge of the footing at an angle of 1H:1V. Maintain side slopes as required by authorities having jurisdiction.

H. Excavation for Pavements: Cut surface under pavements to comply with cross-sections, elevations and grades as shown within a tolerance of plus or minus 0.10-foot.

I. Excavation for Planting Areas: Conform to cross-sections, elevations and dimensions shown, within a tolerance of plus or minus 0.10-foot.

J. Excavation for Trenches

1. Excavate trenches to the depth indicated or required. Carry the depth of trenches for piping to establish the indicated flow lines and invert elevations.

2. Where rock is encountered, carry the excavation 6 inches below the required elevation and backfill with a 6-inch layer of structural fill.

3. Grade bottoms of trenches as indicated, notching under pipe bells to provide solid bearing for the entire body of the pipe.

K. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F.

3.2 SUBGRADE VERIFICATION

A. Following site preparation and excavation for the building, paved surfaces and roadways, the exposed subgrades shall be observed and approved by the Owner's Geotechnical Consultant.

B. Overexcavate any soft, loose or disturbed soils identified by the Geotechnical Consultant and replace with compacted structural fill.

C. If required by Geotechnical Consultant, provide equipment and labor for proof rolling.

3.3 BACKFILL AND FILL

A. For backfill of all excavations, use material sampled and tested by the Owner's Geotechnical Consultant.

B. All fill used for the following shall be structural fill:

1. Fill beneath footings and foundations.

2. Backfill against footings, foundations and structural walls, except 18 inches of gravel backfill for walls shall be placed immediately adjacent to structures for drainage, unless otherwise shown on the drawings.

3. Fill beneath building slabs.

4. Fill within 3 feet vertically of the base of pavements

C. Use nonstructural fill beneath landscaped areas.

D. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Acceptance by Owner's Representative of construction below finish grade including, where applicable, waterproofing, damp proofing, piping, conduits and perimeter insulation.

2. Inspection, testing, approval and recording locations of underground piping and conduits. Coordinate locations with surveyor for as-built survey.

3. Removal of concrete formwork.

4. Removal of shoring, bracing, and backfilling of voids with satisfactory materials.

5. Removal of trash and debris.

6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

E. Ground Surface Preparation

1. Remove vegetation, debris, unsatisfactory soil materials, obstructions and deleterious materials from ground surface prior to placement of fills. On existing sloped surfaces, steeper than 1 vertical to 1.5 horizontal, cut benches into hillsides of 10 feet minimum width and 5 feet maximum height.

2. When existing ground surface has a density less than that specified under "Compaction" for the particular area classification, break up the ground surface, and pulverize, moisture-condition to within 2 percent of the optimum moisture content, and compact to required depth and percentage of maximum density.

F. Placement and Compaction: Allowable thickness of fill lifts will depend on the material type and compaction equipment used. In no case place backfill and fill materials in layers more than 12 inches in loose depth for material compacted by heavy compaction equipment, and more than 6 inches in loose depth for material compacted by hand-operated tampers. For fill deeper than 3 feet below the base of pavements, lifts may be 12 inches maximum in loose depth.

1. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content.

2. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification.

3. Do not place backfill or fill material on surfaces muddy, frozen, or containing frost or ice.

4. Place backfill and fill materials in such a manner as to prevent wedging action of backfill against structures.

3.4 COMPACTION

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area.

B. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum dry density determined in accordance with ASTM D 1557 ("Modified Proctor"):

1. Structures: Compact top 12 inches of subgrade where exposed, and each layer of backfill or fill material to 95 percent of maximum dry density.

2. Building Slabs and Steps: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent of maximum dry density.

3. Lawn or Unpaved Areas: Compact top 12 inches of subgrade and each layer of backfill or fill material to 85 percent of maximum dry density.

4. Walkways: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent of maximum dry density.

5. Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 95 percent of maximum dry density.

6. Utility Bedding and Backfill: Compact each layer of bedding and backfill to 95 percent of maximum dry density.

7. Granular Fill Placed Against Subgrade Walls: Compact to 90-92 percent of maximum with small hand-operated equipment to avoid overcompaction.

C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade, or layer of soil material. Prevent free water from appearing on surface during or subsequent to compaction operations.

1. Remove and replace, or scarify and air dry, soil material too wet to permit compaction to specified density.

2. Soil material removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to a satisfactory value.

3.5 GRADING

A. General: Uniformly grade areas of work including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.

B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces shall be free from irregular surface changes.

C. Compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2-inch when tested with a 10-foot straightedge.

D. Compaction: After grading, compact surfaces to the depth and percentage of maximum density for each area classification.

3.6 WET WEATHER PROVISIONS

A. Native soils are highly sensitive and susceptible to moisture and shall be exported offsite during wet weather or if unable to meet moisture and compaction requirements.

B. Schedule earthwork operations to minimize the potential for erosion, siltation, and disturbance of site soils.

C. Perform earthwork operations in discrete areas as required to minimize the exposure of disturbed soils to wet weather.

D. Compact exposed soil to reduce the infiltration of rainwater.

E. Direct surface water away from fills and excavations.

F. Provide temporary pumping equipment to keep excavations and construction free of water.

G. Soils that become too wet for compaction shall be removed and replaced with compacted structural fill.

3.7 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Transport acceptable excess excavated material to temporary stockpile areas on the Owner's property. Remove any unused excess excavated material from the site, and dispose of legally off the Owners property, prior to final inspection.

B. Remove waste materials, including unacceptable excavated material, trash, and debris and dispose of legally off the Owner's property.

3.8 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction: Allow Owner's Geotechnical Consultant to observe, test and approve subgrades and fill layers before performing further construction work.

B. Footings for structures and retaining walls shall be observed by the Geotechnical Consultant for bearing capacity verification prior to concrete placement. Compaction tests shall be performed if in the opinion of the Geotechnical Consultant they are necessary.

C. If subgrades or fills, which have been placed, are below specified density, provide corrective work as specified at no additional expense.

3.9 PROTECTION

A. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, compact to required density and provide other corrective work as specified, with retesting, prior to further construction.

END OF SECTION 310000

SECTION 311100

CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work includes clearing and grubbing areas within the boundary limits shown on the plans or staked by the Engineer. This work also includes protecting from harm all trees, bushes, shrubs or other objects selected to remain.

1. "Clearing" means removing and disposing of all unwanted material from the surface such as trees, brush, down timber or other natural materials.

2. "Grubbing" means removing and disposing of all unwanted vegetative matter from underground such as sod, stumps, roots, buried logs or other debris.

3. "Debris" means all nonusable natural material produced by clearing and grubbing.

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

3.1 DISPOSAL

A. Disposal shall be in conformance with Section 2-01.2 of the WSDOT Standard Specifications and local jurisdiction requirements except that on-site burning is prohibited.

3.2 CLEARING

A. Clearing shall be in conformance with Section 2-01.3(1) of the WSDOT Standard Specification.

3.3 GRUBBING

A. Grubbing shall be in conformance with Section 2-01.3(2) of the WSDOT Standard Specification.

END OF SECTION 311100

SECTION 321216

ASPHALT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes:

1. Asphalt concrete pavement for roadways and parking

2. Asphalt-treated base beneath roadways and parking

B. Related Sections:

1. 310000 – Earthwork

2. 321613 – Cement Concrete Paving

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

2.1 TACK COAT

A. Tack coat shall by ASTM D977 emulsified asphalt or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted with water at a rate not to exceed one part water to one part emulsified asphalt, of suitable grade and consistency for application.

2.2 ASPHALT CONCRETE

A. Asphalt concrete shall be Class 1/2-inch with aggregate conforming to Section 9-03.8 and asphalt PG 58H-22 conforming to Section 9-02.1(4) of the WSDOT Standard Specifications. Asphalt percentage of the total mixture shall be 5.0 to 7.5 percent.

PART 3 - EXECUTION

3.1 TACK COAT

A. Tack coat shall be placed in conformation with Section 5-04.3(4) of the WSDOT Standard Specifications

3.2 ASPHALT CONCRETE PAVEMENT

A. Construct asphalt concrete pavement in conformance with Section 5-04.3 of the WSDOT Standard Specifications, except as modified herein. Prime coat is not required and tack coat is required as specified therein.

B. Place asphalt concrete pavement more than three inches thick shall in multiple layers. Each layer shall not exceed three inches in thickness or be less than two inches. Asphalt concrete pavement three inches thick or less may be placed in one layer.

C. The Contractor shall pave the entire parking and road areas, including the spaces identified for curbed islands. Following the completion of paving and placement of extruded curbs, the Contractor shall remove asphalt concrete inside the islands as indicated on the drawings.

END OF SECTION 321216

SECTION 321316

DECORATIVE CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Colored concrete paving.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct meeting at Project site.
   1. Review methods and procedures related to decorative concrete paving, including the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and decorative concrete paving construction practices.
   2. Require representatives of each entity directly concerned with decorative concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Ready-mix concrete manufacturer.
      d. Decorative concrete paving Installer.
      e. Manufacturer's representative of decorative concrete paving system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
   1. Environmental Product Declaration (EPD): For each product. For use in Life-Cycle Assessment indicating compliance with LEED requirements.
   2. Health Product Declaration (HDP): For each product.
   3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.

C. Samples for Verification: For each type of exposed color, pattern, or texture indicated.

D. Design Mixtures: For each decorative concrete mixture, include the following:
   1. Alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
   2. In-situ carbon dioxide (CO_2) mineralization.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer, ready-mix concrete manufacturer, and testing agency.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

C. Material Test Reports: For each of the following:
1. Aggregates.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.

B. Ready-Mixed Concrete Manufacturer Qualifications: A firm with a minimum 10 years of experience in manufacturing ready-mixed concrete products and that complies with ASTM C94 requirements for production facilities and equipment.
1. Manufacturer member of NRMCA and certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Mockups: Build mockups in compliance with Section 014339 – Mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
1. Build mockups of full-thickness sections of decorative concrete paving to demonstrate typical joints; surface color, pattern, and texture; curing; and standard of workmanship.
2. Build mockups of decorative concrete paving in location and of size indicated or, if not indicated, build mockups where directed by Architect and not less than 96 inches by 96 inches.
3. Obtain Architect's approval of mockups before start of final unit of Work.
4. Approval of mockups does not constitute approval of deviations from Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
5. Retain and maintain mockups during construction in undisturbed condition as a standard for judging completed Work.
6. Approved mockups may become part of completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with ASTM C94 and ACI 301.

B. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage, and to avoid damaging coatings on steel reinforcement.

1.8 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Comply with ACI 306.1 and the following:
1. Protect concrete Work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures.
2. 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.
3. Do not use frozen materials or materials containing ice or snow.

4. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows:
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.
   a. Contractor's Option: Use of liquid nitrogen to cool concrete.
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

2.2 FORMS

A. As-Cast Surface Form-Facing Material:
1. Form-facing panels that provide full-depth, continuous, straight, true, and smooth exposed concrete surfaces,
2. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Forms for Textured Finish Concrete:
1. Manufacturers: Subject to compliance with requirements, provide the following:
   a. Fast Formliners Co.
   b. Approved substitution.
2. Size, Arrangement, and Configuration: As indicated on Drawings.
3. Face Pattern: As indicated on Drawings Smooth.
4. Provide solid backing and form supports to ensure stability of textured form liners.

C. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
2. Composition: Colorless vegetable-oil based compound.
3. Do not use materials containing diesel oil or petroleum-based compounds.

2.3 STEEL REINFORCEMENT

A. Recycled Content of Steel Products: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 75 percent.

B. Reinforcing Bars: ASTM A615, Grade 60, deformed.

C. Plain Steel Welded-Wire Reinforcement: ASTM A1064, plain, fabricated from as-drawn steel wire into flat sheets.

D. Steel Bar Mats: ASTM A184, fabricated from ASTM A615, Grade 60, deformed bars, assembled with clips.

E. Plain-Steel Wire: ASTM A1064, as drawn.

F. Joint Dowel Bars: ASTM A615, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

G. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place.
   1. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI (DA4) of greater compressive strength than concrete and as follows:
   2. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.4 CONCRETE MATERIALS

A. Source Limitations:
   1. Obtain concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
   2. Obtain each type or class of cementitious material of same brand from same manufacturer's plant.
   3. Obtain aggregate from single source.
   4. Obtain each type of admixture from single source from single manufacturer.

B. Cementitious Materials:
   1. Portland Cement: ASTM C150, gray portland cement, Type I with specified air entrainment admixture, preferred to Type IA and Type IIA air-entrained concrete. Type IIIA acceptable for cold weather construction.
   2. Fly Ash: ASTM C618, Class F or Class C pozzolan, loss on ignition not exceeding 1 percent. Account for lower calcium content of Class F where used.
   3. Slag Cement: ASTM C989, Grade 100 or 120, ground, granulated blast-furnace slag.

C. Normal-Weight Aggregates: ASTM C33, Class 4M, uniformly graded. Provide aggregates from a single source.
   1. Maximum Coarse-Aggregate Size: Maximum 3/4 inch nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

D. Air-Entraining Admixture: ASTM C260M.
   1. Achieve 5 percent entrained air, plus or minus 1-1/2 percent to batch plant concrete mix.

E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
   1. Water-Reducing Admixture: ASTM C494M, Type A.
   2. Water-Reducing and Retarding Admixture: ASTM C494, Type D.
   3. Water-Reducing and Accelerating Admixture: ASTM C494, Type E.

F. In-Situ Carbon Dioxide (CO_2) Mineralization:
   1. Technology that injects post-industrial carbon dioxide (CO_2) into concrete during mixing that becomes chemically-converted into a mineral that causes concrete to undergo mix optimization whereby strength enhancement property of CO_2 is utilized to optimize cementitious content
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. CarbonCure Technologies: CarbonCure Ready Mix Concrete Technology.
      b. Approved substitution.

G. Color Pigment: ASTM C979, synthetic mineral-oxide pigments; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
      a. Davis Colors: Hydrotint or Mix-Ready.
      b. Approved substitution.
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. BASF Construction Systems: MasterColor.
      b. BRICKFORM: BRICKFORM Liquid Integral Color or BRICKFORM Powdered Integral Color.

c. Butterfield Color: Uni-Mix Integral Concrete Colorant - Uni-Mix Liquid Integral Concrete Colorant.
d. Davis Colors: Hydrotint or Mix-Ready.
e. Dayton Superior: Synthetic Iron Oxides.
f. Euclid Chemical Co.: Increte Liquid Integral Color or Colorcrete - Integral Color.
g. Solomon Colors, Inc.: SGS Color-Flo Liquid Colors or SGS Integral Colors for Ready Mix Concrete.

3. Color: Selected by Architect from manufacturer's full range.
4. Color:
   a. Number: 677/.
   b. Name: Outback.
   c. Hex: 948c7b.
5. Dosage Rates: Add the following to each 94 lb. sack of cement
   a. Liquid: 0.59 lbs.
   b. Powder: 0.5 lbs.

H. Water: Potable and complying with ASTM C94.

2.5 FIBER REINFORCEMENT

A. Synthetic Monofilament Micro-Fiber: Monofilament polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C1116, Type III, 1/2 to 1-1/2 inches long.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. BASF Construction Systems: MasterFiber M35 or MasterFiber M70.
      b. Euclid Chemical Co.: PSI Fiberstrand 100 or PSI Fiberstrand 150.
      c. Fibermesh; a Sika Brand: Fibermesh 150e3.
      d. FORTA Corporation: FORTA Econo-Mono.
      e. GCP Applied Technologies Inc.: Sinta M3019.
      f. Sika Corporation: SikaFiber HP.
      g. Approved substitution.
   2. Locations: Interior exposed slabs.
   3. Not for use as replacement for welded-wire fabric.

B. Synthetic Micro-Fiber: Fibrillated polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C1116, Type III, 1/2 to 1-1/2 inches long.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. BASF Construction Systems: MasterFiber F100.
      b. Euclid Chemical Co.: PSI Fiberstrand F.
      c. Fibermesh; a Sika Brand: Fibermesh 300.
      d. FORTA Corporation: FORTA Econo-Net.
      e. GCP Applied Technologies Inc.: Sinta F19.
      f. Sika Corporation: SikaFiber PPF.
      g. Approved substitution.
   2. Locations: Interior slabs schedules for floor coverings, exterior slabs.
   3. Not for use as replacement for welded-wire fabric.

2.6 CURING AND SEALING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete to reduce rapid surface moisture evaporation.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. BASF Construction Systems: MasterKure ER 50. Formerly Confilm
      b. ChemMasters: Spray-Film.
      c. Dayton Superior: AquaFilm J74RTU or AuqaFilm Concentrate J74.
      d. Euclid Chemical Co.: Eucobar.
      e. Kaufman Products, Inc.: VaporAid.

f. Lambert Corporation: LAMBCO Skin.
g. Laticrete International, Inc.: E-CON.
h. Nox-Crete Products Group: Monofilm.
i. Vexcon Chemicals, Inc.: Starseal Assist.
j. W.R. Meadows, Inc.: Evapre or Evapre-RTU.
k. Approved substitution.

2. Concentrated versions of specified products are acceptable subject to concentrates being used according to manufacturers' written instructions.

B. Curing Paper: Nonstaining, waterproof, 8 foot wide paper, consisting of 2 layers of kraft paper cemented together and reinforced with fiber, and complying with ASTM C171.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Fortifiber Building Systems Group: Sisalkraft SK-10.
b. Approved substitution.

C. Waterborne, Membrane-Forming, Curing Compound: ASTM C309, Type 1, Class B, nondissipating, non-yellowing, manufactured for use with colored concrete.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Anti-Hydro International, Inc.: AH Clear Cure WB.
b. BASF Construction Systems: MasterKure CC 160WB.
c. ChemMasters: Safe-Cure & Seal 309.
d. Dayton Superior: Cure & Seal 309 J18.
e. Euclid Chemical Co.: Aqua Cure VOX.
f. Kaufman Products, Inc.: Cure & Seal 309 Emulsion.
g. Laticrete International, Inc.: Dress & Seal WB Dress & Seal WB 30.
h. SpecChem, LLC: Cure & Seal WB 25.
i. TK Products, Division of Sierra Corporation: TK-Tri-Seal.
j. US Mix Co: US SPEC Hydrasheen 15%.
k. W.R. Meadows, Inc.: Vocomp-20 or Vocomp-25.
2. Curing compound shall be pigmented type matching color of integrally colored concrete and shall be approved by coloring admixture manufacturer.
3. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

D. High-Solids, Waterborne, Membrane-Forming, Curing Compound: ASTM C309, Type 1, Class B, 18 to 25 percent solids, nondissipating, non-yellowing, manufactured for use with colored concrete.
1. Curing compound shall be pigmented type matching color of integrally colored concrete and shall be approved by coloring admixture manufacturer.
2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.
3. Products: Subject to compliance with requirements, provide one of the following:
a. BASF Construction Systems: MasterKure CC 1315WB.
b. ChemMasters: Polyseal WB.
c. Dayton Superior: Cure & Seal 1315 J22WB.
d. Euclid Chemical Co.: [**EverClear VOX**] [**Super Aqua-Cure VOX**].
e. Kaufman Products, Inc.: Krystal 25 Emulsion.
f. Laticrete International, Inc.; L&M Dress & Seal WB 30.
g. Nox-Crete Products Group; Cure & Seal 250 E.
h. SpecChem, LLC; Cure & Seal WB 25.
i. Vexcon Chemicals, Inc.: StarSeal 800.
j. W.R. Meadows, Inc.: Vocomp-20 or Vocomp-25.

E. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C1315, Type 1, Class A. Product contains acrylic copolymers.
1. Products: Subject to compliance with requirements, provide one of the following:
a. BASF Construction Systems: MasterKure CC 1315WB.
b. ChemMasters: Polyseal WB.
c. Dayton Superior: Cure & Seal 1315 EF.

d. Euclid Chemical Co.: Super Diamond Clear VOX.
e. Kaufman Products, Inc.: Krystal 25 Emulsion.
f. Lambert Corporation: Crystal Clear Seal 1315 WB.
g. Laticrete International, Inc.: L&M Dress & Seal WB 25.
h. Nox-Crete Products Group: Cure & Seal 250 E.
i. Vexcon Chemicals, Inc.: Starseal 1315.
j. W.R. Meadows, Inc.: Vocomp-30.
k. Approved substitution.

2. Products shall comply with requirements of California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Applications: For interior and exterior concrete surfaces scheduled to remain exposed.

F. Clear Acrylic Sealer, Low-to-Medium Gloss: Manufacturer's standard, waterborne, non-yellowing and UV-resistant, membrane-forming, acrylic copolymer emulsion or epoxy-modified acrylic emulsion, manufactured for colored concrete, containing not less than 15 percent solids by volume.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Bomanite Co: Bomanite Hydrolock.
b. Concrete Sealers USA; TS202 Acrylic WB-25 Topical Sealer.
c. Duckback Products; Clear Acrylic Concrete Sealer DB 6510 - Satin.
d. Epmar Corporation; Quaker Chemical Corporation; Kemiko Clear-A-Thane, Satin.
e. Euclid Chemical Co.: Crystal Clear VOC.
f. H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.; Infusion Water-Based Sealer.
g. QC Construction Products; QC VOC 100 WB.
h. Scofield, a Business Unit of Sika Corporation; CEMENTONE Clear Sealer.
i. United Gilsonite Laboratories (UGL); DRYLOK® Natural Look Sealer.

G. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving surface.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Bomanite Co: Bomanite Sure Trak.
b. Bon Tool Co.: BonWay Gator Grip Slip Resistive Additive.
c. Dayton Superior: Grip Aid.
d. H&C Decorative Concrete Products; a brand of Sherwin-Williams Co.; SharkGrip Slip Resistive Additive.
e. QC Construction Products; QC Sure Trak.
f. Vexcon Chemicals, Inc.: Certi-Vex Grip.

2.7 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Masco Masons Supply Company: Reflex Rubber Joint.
b. Right Pointe Company: Right-Joint Fibre Expansion Joint.
c. SpecChem: SpecFlex Fiber Expansion Joint.
d. W. R. Meadows: FIBRE Expansion Joint.
e. Western Louisville Fiberboard: WLF Expansion Joint.
f. Approved substitution.
2. Thickness: 3/4 inch unless indicated otherwise.
3. Provide for isolation joints at slab and foundation conditions, and where indicated on Drawings.

B. Bonding Agent: ASTM C1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

C. Epoxy Bonding Adhesive: ASTM C881, 2-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
   1. Types I and II, non-load bearing and Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

D. Polyethylene Film: ASTM D4397, 1 mil thick, clear.

2.8 CONCRETE MIXTURES

A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide concrete of consistent quality in appearance and physical properties.

B. Prepare design mixtures for each type and strength of concrete, proportioned on basis of laboratory trial mixture or field test data, or both, according to ACI 301.
   1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows unless indicated otherwise on structural Drawings:
   1. Fly Ash or Other Pozzolans: 25 percent by mass.
   2. Slag Cement: 50 percent by mass.
   3. Combined Fly Ash or Other Pozzolans, and Slag Cement: 50 percent by mass, with fly ash or pozzolans not exceeding 25 percent.

D. 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: 4-1/2 [**5-1/2**] [**2-1/2**] percent plus or minus 1-1/2 percent for 1-1/2 inch nominal maximum aggregate size.
   2. Air Content: 4-1/2 [**6**] [**3**] percent plus or minus 1-1/2 percent for 1 inch nominal maximum aggregate size.
   3. Air Content: 5 [**6**] [**3-1/2**] percent plus or minus 1-1/2 percent for 3/4 inch nominal maximum aggregate size.

E. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 [**0.15**] [**0.30**] percent by weight of cement.

F. Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing, high-range water-reducing, and plasticizing 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.
   3. Use corrosion-inhibiting admixture in concrete mixtures where indicated.

G. In-Situ Carbon Dioxide (CO_2) Mineralization: Provide concrete that has undergone in-situ carbon dioxide (CO_2) mineralization in which concrete undergoes mix optimization whereby strength enhancement property of CO_2 is utilized to optimize cementitious content.
   1. Ensure that CO_2-mineralized and optimized concrete mix meets specified concrete performance requirements specified in this Section.
   2. Architect will review cementitious content and w/c ratios and may require adjustments to ensure compliance with specified performance requirements.

A. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions. Mix until color pigment is uniformly dispersed and results in hardened concrete color consistent with approved mockup.

B. Synthetic Micro-Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.5 lb/cu. yd.

C. Concrete Mixtures: Normal-weight concrete.
   1. Compressive Strength (28 Days): 4,000 psi.
   2. Maximum W/C Ratio at Point of Placement: 0.42 to 0.50 unless indicated otherwise in civil Construction Documents.
   3. Slump Limit: 4 inches, plus or minus 1 inch.

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94 and ASTM C1116. Furnish batch certificates for each batch discharged and used in Work.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes.
   2. When air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
   3. Monitor concrete in truck and reject if temperature rises to 89 deg F or 5 deg F in 10 minutes, indicating that concrete is setting up prior to discharge.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94. Mix concrete materials in appropriate drum-type batch machine mixer.
   1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes, after ingredients are in mixer, before any part of batch is released.
   2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.
   3. Provide batch ticket for each batch discharged and used in Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added.
   4. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll subbase in one direction. Limit vehicle speed to 3 mph.
   2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Division 31 Section for Earth Moving

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

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 INSTALLATION OF STEEL REINFORCEMENT

A. Comply with CRSI (DA4) for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Accurately position, support, and secure reinforcement against displacement.
1. Maintain minimum concrete cover.
2. Do not tack weld crossing reinforcing bars.

D. Install welded-wire reinforcement in lengths as long as practicable.
1. Lap adjoining pieces at least 1 full mesh, and lace splices with wire.
2. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
3. Lace overlaps with wire.

E. Install fabricated bar mats in lengths as long as practicable.
1. Handle units to keep them flat and free of distortions.
2. Straighten bends, kinks, and other irregularities, or replace units as required before placement.
3. Set mats for a minimum 2 inch overlap of adjacent mats.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than 1/2 hour unless paving terminates at isolation joints.
1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Butt Joints: Use epoxy-bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
3. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
4. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt 1/2 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. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
   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 radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
      a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.

   2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt 1/2 of dowel length to prevent concrete bonding to one side of joint.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface 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. Do not add water to fresh concrete after testing.

F. 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.

G. 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 or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating dowels and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

3.8 INTEGRALLY COLORED CONCRETE FINISH

A. Integrally Colored Concrete Finish: After final floating, apply the following finish:
   1. 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.

3.9 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 Compound: Apply immediately after final finishing. 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.
   1. Cure integrally colored concrete with a curing compound.
   2. Cure concrete finished with pigmented mineral dry-shake hardener with a curing compound.

F. Curing and Sealing 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. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating, and repair damage during curing period.

G. Curing Paper: Cure with unwrinkled curing paper in pieces large enough to cover the entire width and edges of slab. Do not lap sheets. Fold curing paper down over paving edges and secure with continuous banks of earth to prevent displacement or billowing due to wind. Immediately repair holes or tears in paper.
   1. Neutralize concrete surfaces and rinse until water is clear. Test surface for residue with clean white cloth. Test surface according to ASTM F710 to ensure pH is between 7 and 8.

H. Allow paving surface to dry before applying stain. Verify readiness of paving to receive stain according to ASTM D4263 by tightly taping 18-by-18-inch, 4-mil-thick polyethylene sheet to a representative area of paving surface. Apply stain only if no evidence of moisture has accumulated under sheet after 16 hours.

I. Reactive Stain: Apply reactive stain to paving surfaces according to manufacturer's written instructions and as follows:
   1. Apply stain by uncolored bristle brush, roller, or high-volume, low-pressure sprayer and immediately scrub into concrete surface with uncolored, acid-resistant nylon-bristle brushes in continuous, circular motion. Do not spread stain after fizzing stops. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
   2. Remove stain residue after four hours by wet scrubbing with commercial-grade detergent recommended by stain manufacturer. Rinse until water is clear. Control, collect, and legally dispose of runoff.

J. Penetrating Stain: Apply to paving surfaces according to manufacturer's written instructions and as follows:

1. Apply first coat of stain to dry, clean surfaces by airless sprayer or by high-volume, low-pressure sprayer.
2. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
3. Rinse until water is clear. Control, collect, and legally dispose of runoff.

3.10 SEALER APPLICATION

A. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat, using same application methods and rates.
   1. Begin sealing dry surface no sooner than 14 days after concrete placement.
   2. Allow stained concrete surfaces to dry before applying sealer.
   3. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.

3.11 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
   1. Elevation: 3/4 inch.
   2. Thickness: Plus 3/8 inch, minus 1/4 inch.
   3. Surface: Gap below 10-foot-long, unleveled straightedge not to exceed 1/2 inch.
   4. Lateral Alignment and Spacing of Dowels: 1 inch.
   5. Vertical Alignment of Dowels: 1/4 inch.
   6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
   7. Joint Spacing: 3 inches.
   8. Contraction Joint Depth: Plus 1/4 inch, no minus.
   9. Joint Width: Plus 1/8 inch, no minus.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C143; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   4. Concrete Temperature: ASTM C1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
   5. Compression Test Specimens: ASTM C31; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
   6. Compressive-Strength Tests: ASTM C39; test one specimen at seven days and two specimens at 28 days.
      a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results 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. Decorative concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.13 REPAIR AND PROTECTION

A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.

C. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

3.14 DECORATIVE CONCRETE PAVING SCHEDULE

A. Patterned Decorative Concrete Paving:
   1. Locations: Install at areas indicated on plans.
   2. Coloring Method: Integrally colored.
   3. Color: As selected by Architect from manufacturer's full range.

END OF SECTION 321316

SECTION 321373

CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cold-applied joint sealants.
   2. Hot-applied joint sealants.
   3. Joint-sealant backer materials.
   4. Primers.

B. Related Requirements:
   1. Section 079200 – Joint Sealants.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct meeting at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
   1. Environmental Product Declaration (EPD): For each product.
   2. Health Product Declaration (HPD): For each product.
   3. Product Data: For sealants, indicating VOC content.
   4. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2 inch wide joints formed between two 6 inch long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Paving-Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.
   3. Joint-sealant formulation.
   4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Certificates: For each type of joint sealant and accessory.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.6 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D5893, Type NS, low modulus, weather- and UV-resistant, immersible.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Crafco Inc.: RoadSaver Silicone.
      b. Dow Chemical Company: Dowsil 888.
      c. Pecora Corporation: 301 NS.
      d. Approved substitution.
   2. Movement Capability: Plus 100 percent/minus 50 percent.

2.3 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.4 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:
   1. Place joint sealants so they fully contact joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING

A. Clean off excess joint sealant as Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

3.5 PROTECTION

A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or

deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from original Work.

3.6 PAVING-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within concrete paving.
   1. Joint Location:
      a. Expansion and isolation joints in concrete paving.
      b. Contraction joints in concrete paving.
      c. Other joints as indicated.
   2. Joint Sealant: Single-component, nonsag, silicone joint sealant.
   3. Joint-Sealant Color: Manufacturer's standard to match surrounding concrete.

B. Joint-Sealant Application: Joints within concrete paving and between concrete and asphalt paving.
   1. Joint Location:
      a. Joints between concrete and asphalt paving.
      b. Joints between concrete curbs and asphalt paving.
      c. Other joints as indicated.
   2. Joint Sealant: Hot-applied, single-component joint sealant.
   3. Joint-Sealant Color: Manufacturer's standard.

END OF SECTION 321373

SECTION 321400

UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete pavers.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct meeting at Project site.

1.3 ACTION SUBMITTALS

A. Product Data:
   1. For materials other than water and aggregates.
   2. For the following:
      a. Pavers.

B. Sustainable Design Submittals:
   1. Environmental Product Declaration (EPD): For each product.

C. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C136.

D. Samples for Verification: For full-size units of each type of unit paver indicated. Assemble no fewer than 5 Samples of each type of unit on suitable backing and grout joints. Include Samples of the following:
   1. Joint materials.
   2. Exposed edge restraints.
   3. Precast concrete curbs.
   4. Granite curbs.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.

C. 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.

D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
   1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C67.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified unit paving installer. Installer's field supervisor shall have Concrete Paver Installer Certification from Interlocking Concrete Pavement Institute (ICPI) with one of the following designations:
   1. Residential Paver Technician Designation.
   2. Commercial Paver Technician Designation.

B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
   1. Subject to compliance with requirements, approved mockups may become part of completed Work if undisturbed at time of Substantial Completion.

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 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.

1.7 FIELD 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 MANUFACTURERS

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.

2.2 CONCRETE PAVERS

A. Concrete Pavers, Solid Paving Units, Normal-Weight Concrete: Solid paving units made from normal-weight concrete with a compressive strength not less than 5,000 psi, water absorption not more than 5 percent according to ASTM C140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C67.
   1. Thickness: 1-3/4 inches.
   2. Face Size and Shape:
      a. 18 inches square.
   3. Color: As selected by Architect from manufacturer's full range.

2.3 AGGREGATE SETTING-BED MATERIALS

A. Graded Aggregate for Subbase: Sound, crushed stone or gravel complying with ASTM D2940, subbase material.

B. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D448 for Size No. 8.

C. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33 for fine aggregate.

D. Stone Screenings for Leveling Course: Sound stone screenings complying with ASTM D448 for Size No. 10.

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 and the following, measured per test methods referenced:
   1. Survivability: Class 2, AASHTO M 288.
   2. Apparent Opening Size: No. 60 sieve, maximum; ASTM D4751.
   3. Permittivity: 0.02 per second, minimum; ASTM D4491.
   4. UV Stability: 50 percent after 500 hours' exposure, ASTM D4355.

F. Drainage Geotextile: Nonwoven needle-punched geotextile fabric, 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. Apparent Opening Size: No. 40 sieve, maximum; ASTM D4751.
   3. Permittivity: 0.5 per second, minimum; ASTM D4491.
   4. UV Stability: 50 percent after 500 hours' exposure, ASTM D4355.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 PREPARATION

A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

C. Proof-roll prepared subgrade according to requirements in Division 31 Section for Earth Moving to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

3.3 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. 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 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.
   1. For concrete pavers, a block splitter may be used.

D. Joint Pattern: As indicated on Drawings.

E. Tolerances:
   1. Do not exceed 1/16 inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.

3.4 AGGREGATE SETTING-BED APPLICATIONS

A. Compact soil subgrade uniformly to at least 95 percent of ASTM D698 laboratory density.

B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. 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. Place separation geotextile over prepared subgrade, overlapping ends and edges at least 12 inches.

D. Place aggregate subbase and base, compact by tamping with plate vibrator, and screed to depth indicated.

E. Place aggregate subbase and base, compact to 100 percent of ASTM D1557 maximum laboratory density, and screed to depth indicated.

F. Place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches.

G. Place leveling course and screed to a thickness of 1 to 1-1/2 inches, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.

H. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3,500 to 5,000 lbf compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least 3 passes across paving with vibrator.
   1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches of uncompacted pavers adjacent to temporary edges.
   2. Before ending each day's Work, compact installed concrete pavers except for 36 inch width of uncompacted pavers adjacent to temporary edges (laying faces).
   3. As Work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches of laying face.
   4. Before ending each day's Work and when rain interrupts Work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.

3.5 REPAIRING AND POINTING

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.

3.6 CLEANING

A. Cleaning: Remove foreign materials from exposed paver surfaces; wash and scrub clean.
   1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.

END OF SECTION 321400

SECTION 321613

CEMENT CONCRETE PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes:

1. Curbs, curbs and gutters, and extruded curbs

2. Sidewalks

3. ADA Ramps

4. Driveways

1.2 STANDARD SPECIFICATIONS

A. All Work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections and the measurement and payment sections do not apply to this document.

1.3 SUBMITTALS

A. Product Data: Technical Product data for each specified product.

B. Prior to scheduling the paving pre-construction meeting, submit the following to the Engineer for approval:

1. A plan showing the proposed location of all pavement joints. Show field verified locations of surface features such as existing pavement joints, sidewalks, curb ramps, curbs, manhole, vault lids, etc. Show the proposed location of joints in relation to the surface features. Demonstrate compliance with the type of joints, dimensions, and spacing shown in the Contract Drawings. Coordinate concrete paving, colors, joints and textures with the landscape plans.

2. Proposed schedule and sequence for concrete placement and pavement related work including jointing and curing.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Portland cement shall conform to Section 9-01 of the WSDOT Standard Specifications. Normal use shall be type II or Type I/II

B. Fine aggregates shall conform to Section 9-03 of the WSDOT Standard Specifications.

2.2 CONCRETE MIXTURES

A. Concrete design mixtures shall conform to Section 6-02.3(2)A of the WSDOT Standard Specifications. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.

1. Proportion mixtures to provide normal-weight concrete for all classes of concrete required by the City of Everett. Use Class 3000 concrete for Curbs, curbs and gutters, and extruded curbs, Sidewalks, ADA Ramps, Driveways.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify base conditions are acceptable for the work anticipated.

B. Verify gradients and elevations of base are correct per plan.

C. Verify, in the presence of City inspector, that the gradients and elevations of the ADA ramp forms comply with ADA and the City of Everett Standards prior to pouring the concrete.

D. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence. Notify the Architect in writing of conditions detrimental to the proper and timely completion of the work.

E. Do not begin installation until all unsatisfactory conditions are resolved. Beginning work constitutes acceptance of site conditions and responsibility for defective installation caused by prior observable conditions.

F. Inspect and verify concrete forms are thoroughly clean, free of defects, and will meet the required paving tolerances. Side forms used for straight sections for curb lines shall not be bent and the gap shall not exceed1/4 inch when measured with a string over a 10 foot long section. Do not use forms with gaps that exceed the 1/4 inch requirement and remove the forms from the project site.

3.2 CONCRETE PLACEMENT

A. Construct curb, curb and gutter, and extruded curb in conformance with Section 8-04.3 of the WSDOT Standard Specifications and the City of Everett Design and Construction Standards and Specifications for Development.

B. Construct sidewalk and ADA ramps in conformance with Section 8-14.3 of the WSDOT Standard Specifications and the City of Everett Standard Drawings 318 through 322. Provide expansion joints for ADA ramp landings and show on the jointing, scoring, and paving submittal plan.

1. Sidewalk cross slopes shall not exceed 2%.

2. ADA ramp slopes shall not exceed 8.3%.

3. ADA ramp wing slopes shall not exceed 10%.

4. ADA ramp landing zone slopes shall not exceed 2%, in any direction.

C. Regardless of elevation tolerances shown above and on the Drawings, construction shall be in strict compliance with ADA requirements or shall be removed and reconstructed to compliance, at Contractor's expense.

D. Construct driveways in conformance with Section 8-06.3 of the WSDOT Standard Specifications as modified by the City of Everett Standard Specifications and Drawings 315, 316, and 317.

3.3 PAVING TOLERANCES

A. Comply with dimensions as shown on the plans with tolerances as follows:

1. Elevation: 1/4 inch

2. Thickness: Plus 3/8 inch, minus 1/4 inch.

3. Surface: Gap below 10-foot- long, unleveled straightedge not to exceed 1/4 inch.

4. Joint Spacing: 3 inches.

5. Contraction Joint Depth: Plus 1/4 inch, no minus.

6. Joint Width: Plus 1/8 inch, no minus.

B. Regardless of elevation tolerances shown above and on the Drawings, construction shall be in strict compliance with ADA requirements or shall be removed and reconstructed to compliance, at Contractor's expense.

3.4 CONCRETE JOINTS AND SCORING

A. Concrete joints and scoring shall meet the requirements of the City of Everett.

B. Standard locations for expansion joints in sidewalks are:

1. To separate concrete driveway, stairways, curb ramps and their landings from sidewalks.

2. Around the vertical barrel of fire hydrants, around utility poles and large diameter underground utility cover castings when located in the sidewalk area.

3. Longitudinally between concrete walks, curbs, paved planting strips and solid masonry or concrete walls where they abut.

4. To match as nearly as possible, the expansion joints in the adjacent pavement and curb when sidewalk abuts to curb.

END OF SECTION 321613

SECTION 321723

PAVEMENT MARKINGS AND SIGNAGE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes:

1. Pavement markings

2. Traffic control signage.

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

2.1 PAINT

A. Paint for pavement markings shall comply with Section 9-34.2 of the WSDOT Standard Specifications. The paint shall be factory mixed, quick drying and nonbleeding. Colors shall be as indicated on the drawings. Refer to the City of Everett Standard Drawings 720 through 724.

2.2 GLASS BEADS

A. Glass beads for pavement markings shall comply with Section 9-34.4 of the WSDOT Standard Specifications

2.3 PLASTIC

A. Plastic for pavement markings shall comply with Section 9-34.3 of the WSDOT Standard Specifications. Refer to the City of Everett Standard Drawing No. 725.

B. Colors shall be as indicated on the drawings.

2.4 SIGNS

A. Traffic control signs shall be reflective sheeting on sheet aluminum conforming to Sections 9-28.8 and 9-28.12 of the WSDOT Standard Specifications. Posts shall conform to Section 9-28.14 of the WSDOT Standard Specifications. Refer to City of Everett Standard Drawings 715 through 719.

PART 3 - EXECUTION

3.1 Pavement markings installation shall conform to Section 8-22.3 of the WSDOT Standard Specifications, except that the Contractor shall be responsible for all layout and control points, striping shall not deviate more than 1/4-inch in 10 feet from a straight line and striping shall not be more than 1-inch from the specified locations. Apply paint striping only after the pavement has fully cured, 14 days minimum, when the pavement is clean and dry, and when the temperature is above 50 degrees F.

3.2 Signs shall be located and installed as shown on the plans. All signposts shall be plumb and all signs shall be level.

END OF SECTION 321723

SECTION 321816.13

PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Unitary, seamless surfacing.
2. Unitary, tile surfacing.
3. Organic loose-fill surfacing.
4. Inorganic loose-fill surfacing.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of protective surfacing.
1. Include plans, sections, placement [**and penetration**] details, and attachment to substrates.
2. Include accessories and edge terminations.
3. Include [**patterns made by varying colors of surfacing**] [**and**] [**details of graphics**].
4. Include fall heights and use zones for equipment and structures specified in Section 116800 – Play Field Equipment and Structures, coordinated with critical heights for protective surfacing.

C. Samples for Initial Selection: For each type of exposed finish.
1. Include Samples of accessories involving color selection.

D. Samples for Verification: For each type of protective surfacing and exposed finish.
1. Include Samples of accessories to verify color and finish selection.
2. Unitary, Seamless Surfacing: Minimum 6 by 6 inches.
3. Unitary, Tile Surfacing: Minimum 6 by 6 inches.
4. Loose-Fill Surfacing: Minimum 1 quart.
5. Edging: 6 inches long by full width and cross section.
6. Stabilizing Mats: Minimum 12 by 12 inches
7. Drainage/Separation Geotextile: Minimum 12 by 12 inches.
8. Drainage Panel: Minimum 6 by 6 inches.
9. Weed-Control Barrier: Minimum 12 by 12 inches

E. Product Schedule: For protective surfacing.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Material Certificates: For each type of loose-fill surfacing.

C. Product Certificates: For each type of unitary surfacing product.

D. Sample Warranty: For manufacturer's special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For playground protective surfacing to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Unitary Tile Units: Full-size units equal to 1 percent of amount installed, but no fewer than 3 units.
   2. Loose Fill: Amount equal to 1 percent of amount installed, but no fewer than 3 units
   3. Edging Units: 3 full-size units.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Mockups: Build mockups to verify selections made under Sample submittals and to set quality standards for materials and execution.
   1. Build mockups for protective surfacing including accessories.
      a. Size: 48 inches by 48 inches.
   2. Approval of mockups does not constitute approval of deviations from Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   3. Subject to compliance with requirements, approved mockups may become part of completed Work if undisturbed at time of Substantial Completion.

1.7 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace components of protective surfacing that fail in materials or workmanship within specified warranty period.
   1. Failures include the following:
      a. Reduction in impact attenuation as measured by reduction of critical fall height.
      b. Deterioration of protective surfacing and other materials beyond normal weathering.
   2. Warranty Period: [**2**] [**3**] [**5**] [**10**] [**15**] years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain protective surfacing materials[**, including loose-fill accessories,**] from single source from single manufacturer.
   1. Provide geosynthetic accessories of each type from source recommended by manufacturer of protective surfacing materials.

2.2 PERFORMANCE REQUIREMENTS

A. Impact Attenuation: Critical fall height tested according to ASTM F1292.

B. Accessibility Standard: Minimum surfacing performance according to ASTM F1951.

2.3 UNITARY, SINGLE-DENSITY, SEAMLESS SURFACING

A. Description: Manufacturer's standard, site-mixed and applied, single-layer material in thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
   1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
   2. Recycled Content: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 95 percent.

3. Composition: Blend of [**recycled**] SBR [**and EPDM**] rubber, particles and binder, forming a wearing and cushioning product.
4. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane.
5. Critical Height: [**3 feet**] [**4 feet**] [**5 feet**] [**6 feet**] [**7 feet**] [**8 feet**] [**9 feet**] [**10 feet**] [**As indicated on Drawings**].
6. Overall Thickness: Not less than [**as required for critical height indicated**] [**1-1/2 inches**] [**2 inches**] [**2-1/2 inches**] [**3 inches**] [**3-1/2 inches**] [**4 inches**] [**as indicated on Drawings**].
7. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
8. Color(s): As selected by Architect from manufacturer's full range.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.4 UNITARY, DUAL-DENSITY, SEAMLESS SURFACING

A. Description: Manufacturer's standard, site-mixed and applied, two-layer material with wearing layer over cushioning layer, with combined, overall thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Recycled Content: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 85 percent.
3. Wearing Layer: Formulation of [**EPDM rubber particles**] [**or**] [**polyurethane granules**], binder, and other organic and inorganic components.
4. Cushioning Layer: Formulation of [**recycled**] SBR particles and binder.
5. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane.
6. Lacquer Topcoat: Manufacturer's standard polyurethane-based formulation.
7. Critical Height: [**3 feet**] [**4 feet**] [**5 feet**] [**6 feet**] [**7 feet**] [**8 feet**] [**9 feet**] [**10 feet**] [**12 feet**] [**As indicated on Drawings**].
8. Overall Thickness: Not less than [**as required for critical height indicated**] [**1-1/2 inches**] [**2 inches**] [**2-1/2 inches**] [**3 inches**] [**3-1/2 inches**] [**4 inches**] [**4-1/2 inches**] [**5 inches**] [**5-1/2 inches**] [**as indicated on Drawings**].
9. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
10. Wearing Layer Color(s): As selected by Architect from manufacturer's full range.
    a. Design: Where [**colored pattern**] [**graphic design**] is required, provide as indicated on Drawings.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.5 UNITARY, TILE SURFACING

A. Description: Manufacturer's standard blend of recycled SBR, EPDM rubber, or PVC particles forming an integral wearing and cushioning material, with overall thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Recycled Content: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 85 percent.
3. Unit Size: [**24 by 24 inches**] [**As indicated on Drawings**].
4. Base Profile: Integral ribbed or grid-patterned underside forming channels for water drainage between protective surfacing and substrate.
5. Edging and Corner Units: Tapered, bevel-edged units that transition from top surface of protective surfacing to the adjacent, lower surface; size compatible with field units maintaining

layout pattern continuity. Provide edging and corner units where protective surfacing does not abut vertical surfaces.

6. Critical Height: [**7 feet**] [**12 feet**] [**As indicated on Drawings**].
7. Overall Thickness: Not less than [**as required for critical height indicated**] [**1-3/4 inches**] [**2-3/4 inches**] [**4 inches**] [**as indicated on Drawings**].
8. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
9. Anchors: Manufacturer's standard for unit, substrate, and location.
10. Tile Color(s): As selected by Architect from manufacturer's full range.
    a. Design: Where [**colored pattern**] [**graphic design**] is required, provide as indicated on Drawings.
11. Filler/Sealant: Manufacturer's standard clear silicone or polyurethane filler/sealant suitable for exterior use.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.6 UNITARY, DUAL-DENSITY, TILE SURFACING

A. Description: Manufacturer's standard [**EPDM**] colored wearing layer bonded to [**recycled**] rubber cushioning layer, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Recycled Content: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 85 percent.
3. Unit Size: [**24 by 24 inches**] [**As indicated on Drawings**].
4. Base Profile: Integral ribbed or grid-patterned underside forming channels for water drainage between protective surfacing and substrate.
5. Edging and Corner Units: Tapered, bevel-edged units that transition from top surface of protective surfacing to the adjacent, lower surface; size compatible with field units maintaining layout pattern continuity. Provide edging and corner units where protective surfacing does not abut vertical surfaces.
6. Critical Height: [**3 feet**] [**4 feet**] [**5 feet**] [**6 feet**] [**7 feet**] [**8 feet**] [**9 feet**] [**10 feet**] [**12 feet**] [**As indicated on Drawings**].
7. Overall Thickness: Not less than [**as required for critical height indicated**] [**1-1/2 inches**] [**2 inches**] [**2-1/4 inches**] [**3 inches**] [**3-1/4 inches**] [**4 inches**] [**4-1/2 inches**] [**5 inches**] [**5-1/2 inches**] [**as indicated on Drawings**].
8. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
9. Anchors: Manufacturer's standard for unit, substrate, and location.
10. [**Wearing Layer**]Color(s): As selected by Architect from manufacturer's full range.
    a. Design: Where [**colored pattern**] [**graphic design**] is required, provide as indicated on Drawings.
11. Filler/Sealant: Manufacturer's standard clear silicone or polyurethane filler/sealant suitable for exterior use.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.7 ORGANIC LOOSE-FILL SURFACING

A. Engineered Wood Fiber: ASTM F2075; containing no bark, leaves, twigs, or foreign or toxic materials; tested for accessibility according to ASTM F1951.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Recycled Content: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 95 percent.

3. Critical Height: [**4 feet**] [**5 feet**] [**7 feet**] [**10 feet**] [**As indicated on Drawings**].
4. Uncompressed Material Depth: Not less than [**as required for critical height indicated**] [**6 inches**] [**9 inches**] [**as indicated on Drawings**].

B. Wood Chips: Random-sized wood chips suitable for mulching trees and shrubs, free of metal scrap and other impurities that can cause injuries[**; complying with the testing and performance requirements for hazardous metals and tramp metal according to ASTM F2075**].

C. Double-Shredded Bark Mulch: Random-sized bark, shredded twice, suitable for mulching trees and shrubs, free of metal scrap and other impurities that can cause injuries[**; complying with the testing and performance requirements for hazardous metals and tramp metal according to ASTM F2075**].

2.8 INORGANIC LOOSE-FILL SURFACING

A. Shredded Rubber: Rubber particles, free from steel wires, rubber dust, and other foreign substances, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Recycled Content: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 95 percent.
3. Critical Height: [**4 feet**] [**5 feet**] [**7 feet**] [**10 feet**] [**As indicated on Drawings**].
4. Uncompressed Material Depth: Not less than [**6 inches**] [**9 inches**] [**as indicated on Drawings**].
   a. Color: As selected by Architect from manufacturer's full range.

B. Inorganic Aggregate Materials: Clean, washed, and free of loam, clay, organic matter, debris, and other foreign substances.
1. Fine Sand: Complying with ASTM C136 for the following sieve analysis test results:
   a. Sieve Sizes and Percent Passing through Screen: No. 16 passing 100 percent, No. 30 passing 98 percent, No. 50 passing 62 percent, No. 100 passing 17 percent, and No. 200 passing zero to 1 percent.
2. Coarse Sand: Complying with ASTM C136 for the following sieve analysis test results:
   a. Sieve Sizes and Percent Passing through Screen: No. 4 passing 98 percent, No. 8 passing 73 percent, No. 16 passing 4 percent, No. 30 passing 1 percent, and No. 50 passing zero to 1 percent.
3. Fine Gravel: Rounded, hard, durable stone, free of sand, with particle size less than 3/8 inch in diameter; complying with ASTM C136 for the following sieve analysis test results:
   a. Sieve Sizes and Percent Passing through Screen: 3/8 inch passing 100 percent, No. 3-1/2 passing 93 percent, No. 4 passing 65 percent, No. 8 passing 8 percent, No. 16 passing 5 percent, and No. 30 passing 4 percent.
4. Medium Gravel: Rounded, hard, durable, riverbed gravel or tumbled stone, free of sand, with particle size less than 1/2 inch in diameter; complying with ASTM C136 for the following sieve analysis test results:
   a. Sieve Sizes and Percent Passing through Screen: 1/2 inch passing 100 percent, 3/8 inch passing 80 percent, 5/16 inch passing 20 percent, No. 4 passing 8 percent, and No. 16 passing 3 percent.
5. Critical Height: [**4 feet**] [**5 feet**] [**As indicated on Drawings**].
6. Uncompressed Material Depth: Not less than [**as required for critical height indicated**] [**9 inches**] [**as indicated on Drawings**].

2.9 LOOSE-FILL ACCESSORIES

A. Edging: Anchored-in-place, weather-resistant containment barrier designed to minimize sharp edges, protrusions, and tripping hazards; formed by interconnected, modular units.

1. Polyethylene Units: UV-light-stabilized[**, 100 percent recycled**] polyethylene, not less than 1/4 inch wall thickness; made into smooth-surfaced [**straight**] [**and**] [**curved**] units with radiused exposed edges and integral, molded-in color; in manufacturer's standard sizes.
   a. Color: As selected by Architect from manufacturer's full range.
2. Metal Units: Steel fabricated with radiused exposed edges and finished with PVC coating, [**straight**] [**right-angled corner**] [**and**] [**curved**] units, in manufacturer's standard sizes.
   a. Color: As selected by Architect from manufacturer's full range.
3. Rubber Units: Compression molded from[**100 percent recycled**] SBR, in manufacturer's standard sizes.
   a. Color: As selected by Architect from manufacturer's full range.
4. Anchor Stakes: Manufacturer's standard, of corrosion-resistant-coated metal or noncorrodible material, designed to be nonprotruding when installed, for connecting units and securing in-place.

B. Stabilizing Mats: Water-permeable PVC or rubber mats tested for impact attenuation according to ASTM F1292[**, with anchoring system designed to anchor mat securely to subgrade through loose fill**], and rated for use in the following locations:
1. Under and in Front of Slide Exits: [**At finished grade of protective surfacing**] [**Below surface of protective surfacing**] [**As indicated on Drawings**].
2. Under and Around Swings: [**At finished grade of protective surfacing**] [**Below surface of protective surfacing**] [**As indicated on Drawings**].
3. Around Transfer Stations at Accessible Perimeter: At finished grade of protective surfacing.
4. At high-traffic areas and playground equipment where indicated on Drawings.
5. Size: [**Manufacturer's standard size as recommended in writing**] [**36 by 36 inches**] [**40 by 40 inches**] [**48 by 48 inches**].
6. Color: As selected by Architect from manufacturer's full range.

2.10 GEOSYNTHETIC ACCESSORIES

A. Drainage/Separation Geotextiles: Comply with Division 32 Section for Earth Moving.

B. Drainage/Separation Geotextile: Nonwoven, needle-punched geotextile, manufactured for drainage applications and made from polyolefins or polyesters; with the following minimum properties:
1. Fabric: Nonwoven, needle-punched geotextile, specifically manufactured as a filter geotextile and made from polyolefins or polyesters; with the following minimum properties:
   a. Weight: 4 oz./sq. yd. according to ASTM D5261.
   b. Water Flow Rate: 100 gpm/sq. ft. 150 gpm/sq. ft. according to ASTM D4491.
2. Minimum Flow Rate: 9 gpm/foot according to ASTM D4491.

C. Drainage Panel: Prefabricated, composite drainage panels made with drainage core and filter fabric.
1. Drainage Core: 3-dimensional, nonbiodegradable, molded-plastic-sheet material designed to effectively drain water under maximum fill pressures.
2. Fabric: Nonwoven, needle-punched geotextile, specifically manufactured as a filter geotextile and made from polyolefins or polyesters; with the following minimum properties:
   a. Weight: 4 oz./sq. yd. according to ASTM D5261.
   b. Water Flow Rate: 100 gpm/sq. ft. 150 gpm/sq. ft. according to ASTM D4491.
3. Minimum Flow Rate: 9 gpm/foot according to ASTM D4491.

D. Weed-Control Barrier: Composite fabric geotextile consisting of woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, weighing not less than 4.8 oz./sq. yd..

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for subgrade elevations, slope, and drainage and for other conditions affecting performance of the Work.
   1. Verify that substrates are sound and without high spots, ridges, holes, and depressions.

B. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary, protective surfacing installation and that substrate surfaces are dry, cured, and uniformly [**level**] [**sloped to drain**] within recommended tolerances according to protective surfacing manufacturer's written requirements for cross-section profile.
   1. Asphalt Substrates: Verify that substrates are dry, sufficiently cured to bond with adhesive, and free from surface defects, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with protective surfacing or that may interfere with adhesive bond.
   2. Concrete Substrates: Verify that substrates are dry and free from surface defects, laitance, glaze, efflorescence, curing compounds, form-release agents, hardeners, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with protective surfacing or that may interfere with adhesive bond. Determine adhesion, dryness, and acidity characteristics by performing procedures recommended in writing by protective surfacing manufacturer.

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

3.2 PREPARATION

A. Prepare substrates to receive surfacing products according to protective surfacing manufacturer's written instructions.

B. Hard-Surface Substrates: Clean surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with protective surfacing.
   1. Repair: Fill holes and depressions in unsatisfactory surfaces with leveling and patching material.
   2. Treatment: Mechanically abrade or otherwise prepare concrete substrates according to protective surfacing manufacturer's written instructions to achieve adequate roughness.
   3. Terminal Edges: Saw cut [**concrete**] [**asphalt**] for terminal edges of protective surfacing.
   4. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through protective surfacing.

3.3 INSTALLATION OF GEOSYNTHETIC ACCESSORIES

A. Install geosynthetic accessories before edging and according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions and in a manner that cannot become a tripping hazard.
   1. Drainage/Separation Geotextile: Completely cover area beneath protective surfacing, overlapping geotextile sides and edges a minimum of [**4 inches**] [**8 inches**] with [**manufacturer's standard treatment for**] [**overlapping loosely laid**] [**adhesively bonded or taped**] seams.
   2. Drainage Panels: Completely cover area beneath protective surfacing, abutting the drainage cores and overlapping seams with geotextile fabric facing with [**manufacturer's standard treatment**] [**overlapping loosely laid**] [**adhesively bonded or taped**] seams.
   3. Weed-Control Barrier: Completely cover area beneath loose-fill installation, overlapping barrier edges a minimum of [**4 inches**] [**8 inches**] with [**manufacturer's standard treatment for**] [**overlapping loosely laid**] [**adhesively bonded or taped**] seams.

3.4 INSTALLATION OF SEAMLESS SURFACING

A. Mix and apply components of seamless surfacing according to manufacturer's written instructions to produce uniform, monolithic, and impact-attenuating protective surfacing of required overall thickness.
   1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
   2. Poured Cushioning Layer: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
   3. Intercoat Primer: Over cured cushioning layer, apply primer at manufacturer's standard spreading rate.
   4. Wearing Layer: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with [**no**] [**a minimum of**] cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
      a. Design: Where [**colored pattern**] [**graphic design**] is required, place colored, design material as soon as previously placed material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.
   5. Lacquer Topcoat: Spray or roller applied at manufacturer's standard coating rate in one continuous operation.
   6. Edge Treatment: [**Flush**] [**Extended surface course**] [**Saw-cut base and vertical pour**] [**As indicated on Drawings**]. Fully adhere edges to substrate with full coverage of substrate. Maintain fully cushioned thickness required to comply with performance requirements.

3.5 INSTALLATION OF TILE SURFACING

A. Apply components of tile surfacing according to manufacturer's written instructions to produce a uniform wearing surface with no unaligned units, raised edges (lipping), or other surface imperfections.

B. Lay out units from center marks established between principal perimeter edges, discounting minor offsets, so units at opposite sides of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit.[**Allow for edging.**]
   1. Alignment Axis and Pattern: Lay units along axis and in grid pattern indicated on Drawings.
   2. Alignment Axis and Pattern: Lay units [**square**] [**at a 45-degree angle**] with playground equipment axis. Lay units in straight-line grid pattern with joints aligned.
   3. Alignment Axis and Pattern: Lay units [**square**] [**at a 45-degree angle**] with playground equipment axis. Lay units in half-unit, offset grid pattern with staggered joints.

C. Cut and fit units around playground equipment supports and vertical surfaces. Do not create voids greater than 3/8 inch wide.
   1. Do not stretch units during installation.

D. Adhesively Applied Units: Adhere units to substrates using a full spread of adhesive applied to substrate or to unit[**and to each other**].

E. Mechanically Fastened Units: Anchor to substrates.

F. Mechanically Attached Units: Attach all four sides of units[**, including edging and corner units,**] to each other using number of fasteners per side as recommended in writing by protective surfacing manufacturer.
   1. Free lay sheet of attached units on substrate.
   2. Adhesively apply perimeter units. Adhere not less than one course of perimeter units[**and edging and corner units**] to substrates using a full spread of adhesive applied to substrate or to unit[**and to each other**].

G. Edging: Maintain fully cushioned thickness required to comply with performance requirements.

H. Filler/Sealant: Mask area surrounding cutouts around playground equipment supports and other obstructions. Apply a full bead of filler/sealant, filling cutouts immediately after laying tile around cutout.

3.6 INSTALLATION OF LOOSE-FILL SURFACING

A. Apply components of loose-fill surfacing according to manufacturer's written instructions to produce a uniform surface.

B. Edging: Place and permanently secure edging in place, and attach units to each other.

C. Loose Fill: Place loose-fill materials to required depth after installation of playground equipment support posts and foundations.[**Include manufacturer's recommended amount of additional material to offset natural compaction over time.**][**Include manufacturer's recommended amount of additional material to offset mechanical compaction.**]

D. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing[**and compacting**] loose fill.

E. Grading: Uniformly grade loose fill to an even surface free from irregularities.

F. Compaction: After initial grading, mechanically compact loose fill before finish grading.

G. Finish Grading: Hand rake to a uniformly smooth finished surface and to required elevations.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests.

B. Playground protective surfacing will be considered defective if it does not pass tests.

C. Prepare test reports.

3.8 PROTECTION

A. Prevent traffic over [**seamless**] [**tile**] surfacing for not less than 48 hours after installation.

END OF SECTION 321816.13

SECTION 323300

SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Seating.
2. Tables.
3. Trash receptacles.
4. Ash receptacles.
5. Bollards.
6. Park-Style Charcoal Grills.

B. Related Requirements:
1. Section 323313 – Site Bicycle Racks and Lockers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
1. Chain-of-Custody Certificates: For certified wood products. Include statement of costs.

C. Samples for Verification: For each type of exposed finish, not less than 6 inch long linear components and 4 inch-square sheet components.
1. Include full-size Samples of table, trash receptacle, and ash receptacle. Approved samples may be incorporated into Work.

D. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For site furnishings to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 SEATING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Canterbury International.
2. Creative Pipe, Inc.
3. DuMor Inc.
4. fermob
5. Fibrex Group Inc. (The).
6. Forms+Surfaces.
7. Landscape Forms.
8. mmcité 7 LLC
9. Neenah Foundry Company.
10. Ore Incorporated.
11. Recreation Creations, Inc.
12. Sitecraft.
13. Smith & Hawken, Ltd.

14. SportsPlay Equipment, Inc.
15. Tournesol Siteworks, LLC.
16. Urban Accessories, Inc.
17. Approved substitution.

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert Product**> by <**Insert Manufacture**> or comparable product by one of the following:
1. fermob
2. Forms+Surfaces.
3. Landscape Forms.
4. mmcité 7 LLC
5. Approved substitution.

C. Frame: [**Cast aluminum**] [**Cast iron**] [**Steel**] [**Stainless steel**] [**Wrought iron**] [**Cedar**] [**Teak**].

D. Seat[**and Back**]:
1. Material:
   a. Aluminum Sheet: [**Perforated**] [**Expanded**] metal.
   b. [**Painted**]Steel: [**Perforated metal**] [**Expanded metal**] [**Evenly spaced, parallel flat straps or bars**] [**Evenly woven, flat straps or bars**] [**Edge framed, evenly spaced, parallel rods or rolled bars**].
   c. Stainless Steel: [**Perforated metal**] [**Expanded metal**] [**Evenly spaced, parallel flat straps or bars**] [**Evenly woven, flat straps or bars**] [**Edge framed, evenly spaced, parallel rods or rolled bars**].
   d. Wood: [**Douglas fir**] [**Pine**] [**Cedar**] [**Redwood**] [**Teak**]; formed into [**evenly spaced parallel slats**] [**planks**].
   e. [**Recycled**] [**Plastic**] [**Fiberglass**] Planks: Evenly spaced, parallel.
   f. [**Recycled**] [**Plastic**] [**Fiberglass**] Sheet: [**Solid**] [**Perforated**].
2. Seat Height: As indicated.
3. Seat Surface Shape: [**Flat**] [**Contoured or dished**].
4. Overall Height: As indicated.
5. Overall Width: As indicated.
6. Overall Depth: As indicated.
7. Arms: [**None**] [**1, as indicated**] [**2, 1 at each end**] [**3, 1 at each end and in center**].
   a. Arm Material: Match [**frame**] [**seat**].
8. Weight: <**Insert weight**>.
9. Seating Configuration: Multiple units[**as indicated**].
   a. [**Straight**] [**Angled**] [**Curved**] shape.
   b. Closed [**hexagon**] [**circle**] [**shape indicated**] around a [**tree trunk**] [**planter**] [**light post**].

E. Benches: Fabricated, surface-mounted, backed benches meeting the following requirements:
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
   a. Landscape Forms: Austin Bench.
   b. Approved substitution.
2. Overall Height: 33 inches.
3. Overall Width: 72 inches.
4. Overall Depth: 24 inches.
5. Material:
   a. Wood: Select South American Ipe; formed into evenly spaced parallel slats.
6. Arms: 3, 1 at each end and in center.
   a. Arm Material: Aluminum.
7. Supports: Cantilevered-style, aluminum.
8. Weight: Approximately 130 lbs.
9. Seating Configuration: Single units.
   a. Straight shape.

10. Finishes:
    a. Wood: No finish applied.
    b. Supports and Arms: Manufacturer's standard powder coat finish.
        1) Color and Gloss: As selected by Architect from manufacturer's full standard color range.

F. Benches: Fabricated, surface-mounted, backed benches meeting the following requirements:
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
    a. DuMor, Inc.: 58 Series Bench.
    b. Approved substitution.
2. Material:
    a. Painted Steel: Evenly spaced, parallel flat straps or bars.
3. Seat Height: 17-1/16 inches.
4. Seat Surface Shape: Contoured or dished.
5. Overall Height: 31-11/16 inches.
6. Overall Width: 73 [**97**] inches.
7. Overall Depth: As indicated.
8. Arms: 2, 1 at each end.
    a. Arm Material: Match frame.
9. Weight: 300 [**361**] lbs.
10. Seating Configuration: Single units.
    a. Straight shape.
11. Finish: Manufacturer's standard powder coat finish.
    a. Color and Gloss: As selected by Architect from manufacturer's full standard color range.

G. Benches: 100 percent high-density polyethylene (HDPE) derived from recycled post-consumer packaging with added pigment and UV inhibitors for a minimum of 90 percent recycled content by weight.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
    a. Landscape Forms: Balustrade Bench.
    b. Approved substitution.
2. Timbers: Extruded face and interior board with eased edges and ends in sizes as follows:
    a. Face Boards: 3 inch by 4 inch nominal.
    b. Interior Boards: 1-1/4 inch by 1-1/2 inch.
3. Bench Size: 25 inches deep by 72 inches long.
4. Supports: Square, tubular steel, surface-mounted type with manufacturer's standard metal straps for mounting timbers to frame.
    a. Finish: Manufacturer's standard rust inhibitive primer with UV -resistant, thermosetting polyester powdercoat finish in Grotto.

H. Benches: Fabricated from recycled steel with fully-welded seams:
1. Basis-of-Design Product: Subject to compliance with requirements, provide 3003 Cantilever Bench by Ore, Inc. or approved substitution.
2. Dimensions: 54 inches long by 15.5 inches wide by 17.5 inches high.
3. Powder-Coated Finish: Apply manufacturer's standard primer and thermosetting polyester powder coating. Prepare, treat, and coat metal to comply with resin manufacturer's written instructions.
    a. Color: Black.

I. Aluminum Finish: [**Mill finish**] [**Color coated**].
1. Color: As selected by Architect from manufacturer's full range.

J. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
1. Color: As selected by Architect from manufacturer's full range.

K. Stainless Steel Finish: ASTM A480, No. 6.

L. Wood Finish: [Unfinished] [Factory-applied transparent finish] [Factory-applied stain and transparent finish] [Factory-applied opaque finish] [Manufacturer's standard finish].
   1. Stain: Manufacturer's standard.

M. [**Fiberglass**] [**HDPE**] Color: As selected by Architect from manufacturer's full range.

N. Graphics: [**Surface-applied**] [**Engraved**] [**Attached brass plaque with engraved**] copy, content, and style [**according to manufacturer's standard**] [**as indicated on Drawings**].

2.2 TABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Canterbury International.
   2. Creative Pipe, Inc.
   3. DuMor Inc.
   4. fermob
   5. Fibrex Group Inc. (The).
   6. Forms+Surfaces.
   7. Landscape Forms.
   8. mmcité 7 LLC
   9. Neenah Foundry Company.
   10. Ore Incorporated.
   11. Recreation Creations, Inc.
   12. Sitecraft.
   13. Smith & Hawken, Ltd.
   14. SportsPlay Equipment, Inc.
   15. Tournesol Siteworks, LLC.
   16. Urban Accessories, Inc.
   17. Approved substitution.

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert Product**> by <**Insert Manufacture**> or comparable product by one of the following:
   1. fermob
   2. Forms+Surfaces.
   3. Landscape Forms.
   4. mmcité 7 LLC
   5. Approved substitution.

C. Frame: [**Cast aluminum**] [**Cast iron**] [**Steel**] [**Stainless steel**] [**Wrought iron**] [**Cedar**] [**Teak**].

D. Table Top:
   1. Material:
      a. Aluminum Sheet: [**Perforated**] [**Expanded**] metal.
      b. [**Painted**]Steel: [**Perforated metal**] [**Expanded metal**] [**Evenly spaced, parallel flat straps or bars**] [**Evenly woven, flat straps or bars**] [**Edge framed, evenly spaced, parallel rods or rolled bars**].
      c. Stainless Steel: [**Perforated metal**] [**Expanded metal**] [**Evenly spaced, parallel flat straps or bars**] [**Evenly woven, flat straps or bars**] [**Edge framed, evenly spaced, parallel rods or rolled bars**].
      d. Wood: [**Douglas fir**] [**Pine**] [**Cedar**] [**Redwood**] [**Teak**]; formed into [**evenly spaced parallel slats**] [**planks**].
      e. [**Recycled**] [**Plastic**] [**Fiberglass**] Planks: Evenly spaced, parallel.
      f. [**Recycled**] [**Plastic**] [**Fiberglass**] Sheet: [**Solid**] [**Perforated**].
   2. Surface Shape: [**Round**] [**Hexagon**] [**Shape indicated**].
   3. Feature: Center umbrella hole.

E. Aluminum Finish: [**Mill finish**] [**Color coated**].

1. Color: [**As indicated by manufacturer's designation**] [**Match Architect's samples**] [**As selected by Architect from manufacturer's full range**] [**As indicated in a site furnishing schedule**].

F. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
1. Color: [**As indicated by manufacturer's designation**] [**Match Architect's samples**] [**As selected by Architect from manufacturer's full range**] [**As indicated in a site furnishing schedule**].

G. Stainless Steel Finish: ASTM A480, No. 6.

H. Wood Finish: [**Unfinished**] [**Factory-applied transparent finish**] [**Factory-applied stain and transparent finish**] [**Factory-applied opaque finish**] [**Manufacturer's standard finish**].
1. Stain: Manufacturer's standard.

I. [**Fiberglass**] [**HDPE**] Color: [**As indicated by manufacturer's designation**] [**Match Architect's samples**] [**As selected by Architect from manufacturer's full range**] [**As indicated in a site furnishing schedule**].

J. Graphics: [**Surface-applied**] [**Engraved**] [**Attached brass plaque with engraved**] copy, content, and style [**per manufacturer's standard**] [**as indicated on Drawings**].

2.3 TRASH RECEPTACLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Canterbury International.
2. Creative Pipe, Inc.
3. DuMor Inc.
4. fermob
5. Fibrex Group Inc. (The).
6. Forms+Surfaces.
7. Landscape Forms.
8. mmcité 7 LLC
9. Neenah Foundry Company.
10. Ore Incorporated.
11. Recreation Creations, Inc.
12. Sitecraft.
13. Smith & Hawken, Ltd.
14. SportsPlay Equipment, Inc.
15. Tournesol Siteworks, LLC.
16. Urban Accessories, Inc.
17. Approved substitution.

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert Product**> by <**Insert Manufacture**> or comparable product by one of the following:
1. fermob
2. Forms+Surfaces.
3. Landscape Forms.
4. mmcité 7 LLC
5. Approved substitution.

C. Aluminum Facing Surrounds: [**Aluminum sheet**] [**Perforated aluminum sheet**] [**Grid in tubular frame**] [**Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes**] [**Match benches**].

D. Steel Facing Surrounds: [**Steel sheet**] [**Perforated-steel sheet**] [**Evenly patterned, parallel flat steel straps, bars, or tubular shapes**] [**Evenly patterned, parallel round steel rods, bars, or tubular shapes**] [**Grid in tubular frame**] [**Match benches**].

E. Stainless Steel Facing Surrounds: [**Steel sheet**] [**Perforated-steel sheet**] [**Evenly patterned, parallel flat steel straps, bars, or tubular shapes**] [**Evenly patterned, parallel round steel rods, bars, or tubular shapes**] [**Grid in tubular frame**] [**Match benches**].

F. Wood Facing Surrounds: [**Evenly spaced, Douglas fir slats**] [**Evenly spaced pine slats**] [**Evenly spaced cedar slats**] [**Redwood panels**] [**Evenly spaced redwood slats**] [**Teak panels**] [**Evenly spaced teak slats**] [**Match benches**].

G. Fiberglass Facing Surrounds: Molded fiberglass shape.

H. Plastic Facing Surrounds: [**Molded HDPE shape**] [**Evenly spaced HDPE slats**] [**Evenly spaced, recycled HDPE slats**] [**Match benches**].

I. Support Frames: [**Steel**] [**Galvanized steel**]; welded.

J. Trash Receptacles:
   1. Receptacle Shape and Form: [**Round cylinder**] [**Round cylinder with tapered funnel top**] [**Round, tapered column**] [**Square column**] [**Rectangular column**] [**As indicated**]; with opening for depositing trash in [**lid or top**] [**side of lid or top**] [**receptacle side**].
   2. Lids and Tops: [**Matching facing panels**] [**Aluminum**] [**Steel**] [**HDPE**] [**Recycled HDPE**] secured by cable or chain, hinged, swiveled, or permanently secured.
      a. Description: [**Flat rim ring lid with center opening**] [**Dome top**] [**Arched top**] [**Elevated flat or shallow dome rain-cap lid**] [**Combination ash sand pan and rim lid**] [**Combination ash sand pan and dome top**] [**Combination ash sand pan and elevated flat or shallow dome rain-cap lid**].
      b. Opening for depositing trash covered by [**self-closing, spring-loaded-hinged, push-in**] [**rotating**] weather flap.
   3. Receptacle Height: As indicated.
   4. Overall Width: As indicated.
   5. Weight: <**Insert weight**>.
   6. Inner Container: [**Aluminum**] [**Galvanized-steel sheet**] [**Perforated-metal**] [**Fiberglass**] [**Rigid plastic**] container with [**drain holes**] [**lift-out handles**]; designed to be removable and reusable.
   7. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
   8. Capacity: Not less than [**22 gal.**] [**28 gal.**] [**30 gal.**] [**32 gal.**] [**40 gal.**] [**55 gal.**].
   9. Service Access: [**Removable lid or top**] [**Fixed lid or top, side access**]; inner container and disposable liner lift or slide-out for emptying[**; lockable with padlock hasps**] [**; keyed lock with 2 keys per receptacle**] [**; self-latching hinge**].
   10. Post Mount: [**Color-coated steel pipe; color to match receptacle**] [**Galvanized-steel pipe**] [**Wood**]; for mounting [**1**] [**2**] [**3**] receptacle(s).

K. Aluminum Finish: [**Mill finish**] [**Color coated**].
   1. Color: As selected by Architect from manufacturer's full range.

L. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
   1. Color: As selected by Architect from manufacturer's full range.

M. Stainless Steel Finish: ASTM A480, No. 6.

N. Wood Finish: [**Unfinished**] [**Factory-applied transparent finish**] [**Factory-applied stain and transparent finish**] [**Factory-applied opaque finish**] [**Manufacturer's standard finish**].
   1. Stain: [**Manufacturer's standard**] <**Insert stain type and color**>.

O. [**Fiberglass**] [**HDPE**] Color: As selected by Architect from manufacturer's full range.

P. Graphics: [**Surface-applied**] [**Engraved**] [**Attached brass plaque with engraved**] copy, content, and style [**according to manufacturer's standard**] [**as indicated on Drawings**].
   1. Copy: [**Litter**] [**Trash**] [**Waste**] [**Recycle**].

2.4 ASH RECEPTACLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Canterbury International.
   2. Creative Pipe, Inc.
   3. DuMor Inc.
   4. fermob
   5. Fibrex Group Inc. (The).
   6. Forms+Surfaces.
   7. Landscape Forms.
   8. mmcité 7 LLC
   9. Neenah Foundry Company.
   10. Ore Incorporated.
   11. Recreation Creations, Inc.
   12. Sitecraft.
   13. Smith & Hawken, Ltd.
   14. SportsPlay Equipment, Inc.
   15. Tournesol Siteworks, LLC.
   16. Urban Accessories, Inc.
   17. Approved substitution.

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert Product**> by <**Insert Manufacture**> or comparable product by one of the following:
   1. fermob
   2. Forms+Surfaces.
   3. Landscape Forms.
   4. mmcité 7 LLC
   5. Approved substitution.

C. Aluminum Facing Surrounds: [**Aluminum sheet**] [**Perforated aluminum sheet**] [**Grid in tubular frame**] [**Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes**] [**Match benches**].

D. Steel Facing Surrounds: [**Steel sheet**] [**Perforated-steel sheet**] [**Evenly patterned, parallel flat steel straps, bars, or tubular shapes**] [**Evenly patterned, parallel round steel rods, bars, or tubular shapes**] [**Grid in tubular frame**] [**Match benches**].

E. Stainless Steel Facing Surrounds: [**Steel sheet**] [**Perforated-steel sheet**] [**Evenly patterned, parallel flat steel straps, bars, or tubular shapes**] [**Evenly patterned, parallel round steel rods, bars, or tubular shapes**] [Gri**d in tubular frame**] [**Match benches**].

F. Fiberglass Facing Surrounds: Molded fiberglass shape.

G. Support Frames: [**Steel**] [**Galvanized steel**]; welded.

H. Ash Receptacles:
   1. Receptacle Shape and Form: [**Round cylinder**] [**Round cylinder with tapered funnel top**] [**Round, tapered column**] [**Square column**] [**Rectangular column**] [**As indicated**]; with opening for depositing trash in [**lid or top**] [**side of lid or top**] [**receptacle side**].
   2. Function: [**Uncovered receptacle with sand pan**] [**Uncovered receptacle with bowl and funnel**] [**Covered receptacle with sand pan**] [**Covered receptacle with bowl and screen**] [**Covered receptacle with slots**] [**Uncovered receptacle with sand pan attaching to side**

of trash receptacle] for depositing cigarette butts; fire-proof design; bowl and pan removable for cleaning.

3. Lids and Tops: [**Matching facing panels**] [**Aluminum**] [**Steel**] [**HDPE**] [**Recycled HDPE**] secured by cable or chain, hinged, swiveled, or permanently secured.
   a. Description: [**Flat rim ring lid with center opening**] [**Dome top**] [**Arched top**] [**Elevated flat or shallow dome rain-cap lid**] [**Combination ash sand pan and rim lid**] [**Combination ash sand pan and dome top**] [**Combination ash sand pan and elevated flat or shallow dome rain-cap lid**].
4. Receptacle Height: As indicated.
5. Overall Width: As indicated.
6. Weight: <**Insert weight**>.
7. Post Mount: [**Color-coated steel pipe; color to match receptacle**] [**Galvanized-steel pipe**] [**Wood**]; for mounting [**1**] [**2**] [**3**] receptacle(s).
8. Accessories: [**Sand sifter**] [**Butt stub-out**].

I. Aluminum Finish: [**Mill finish**] [**Color coated**].
   1. Color: As selected by Architect from manufacturer's full range.

J. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
   1. Color: As selected by Architect from manufacturer's full range.

K. Stainless Steel Finish: ASTM A480, No. 6.

L. [**Fiberglass**] [**HDPE**] Color: As selected by Architect from manufacturer's full range.

2.5 PLANTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Canterbury International.
   2. Creative Pipe, Inc.
   3. DuMor Inc.
   4. fermob
   5. Fibrex Group Inc. (The).
   6. Forms+Surfaces.
   7. Landscape Forms.
   8. mmcité 7 LLC
   9. Neenah Foundry Company.
   10. Ore Incorporated.
   11. Recreation Creations, Inc.
   12. Sitecraft.
   13. Smith & Hawken, Ltd.
   14. SportsPlay Equipment, Inc.
   15. Tournesol Siteworks, LLC.
   16. Urban Accessories, Inc.
   17. Approved substitution.

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert Product**> by <**Insert Manufacture**> or comparable product by one of the following:
   1. fermob
   2. Forms+Surfaces.
   3. Landscape Forms.
   4. mmcité 7 LLC
   5. Approved substitution.

C. Aluminum Facing Surrounds: [**Aluminum sheet**] [**Perforated aluminum sheet**] [**Grid in tubular frame**] [**Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes**] [**Match benches**].

D. Steel Facing Surrounds: [**Steel sheet**] [**Perforated-steel sheet**] [**Evenly patterned, parallel flat steel straps, bars, or tubular shapes**] [**Evenly patterned, parallel round steel rods, bars, or tubular shapes**] [**Grid in tubular frame**] [**Match benches**].

E. Steel Facing Surrounds, Cylindrical Style: Steel sheet. Provide planters with manufacturer's standard drain holes.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
      a. Ore, Inc.: 1202 [**1201**] [**1200**] Series Cylinder planter.
      b. Approved substitution.
   2. Overall Height: 22 [**20**] [**18**] inches.
   3. Overall Width: 30 [**25**] [**20**] inch diameter.
   4. Base: 24 [**21**] [**16**] inch diameter.
   5. Capacity: 7.5 [**4.5**] [**2.5**] cubic feet.

F. Steel Facing Surrounds, Rectangular Style: Steel sheet. Provide planters with manufacturer's standard drain holes.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
      a. Ore, Inc.: 1108 Small High Rectangle planter.
      b. Approved substitution.
   2. Dimensions, Planter:
      a. Height: 24 inches.
      b. Width: 25 inches.
      c. Depth: 20 inches.
   3. Dimensions, Base:
      a. Height: 3 inches.
      b. Width: 19 inches.
      c. Depth: 16 inches.
   4. Capacity: 6.5 cubic feet
   5. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
      a. Color: As selected by Architect from manufacturer's full range.

G. Steel Facing Surrounds, Rectangular Style: Steel sheet. Provide planters with manufacturer's standard drain holes.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
      a. Ore, Inc.: 1109 Medium High Rectangle planter.
      b. Approved substitution.
   2. Dimensions, Planter:
      a. Height: 24 inches.
      b. Width: 42 inches.
      c. Depth: 20 inches.
   3. Dimensions, Base:
      a. Height: 3 inches.
      b. Width: 36 inches.
      c. Depth: 16 inches.
   4. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
      a. Color: As selected by Architect from manufacturer's full range.

H. Stainless Steel Facing Surrounds: [**Steel sheet**] [**Perforated-steel sheet**] [**Evenly patterned, parallel flat steel straps, bars, or tubular shapes**] [**Evenly patterned, parallel round steel rods, bars, or tubular shapes**] [Gri**d in tubular frame**] [**Match benches**].

I. Wood Facing Surrounds: [**Evenly spaced, Douglas fir slats**] [**Evenly spaced pine slats**] [**Evenly spaced cedar slats**] [**Redwood panels**] [**Evenly spaced redwood slats**] [**Teak panels**] [**Evenly spaced teak slats**] [**Match benches**].

J. Fiberglass Facing Surrounds: Molded fiberglass shape.

K. Plastic Facing Surrounds: [**Molded HDPE shape**] [**Evenly spaced HDPE slats**] [**Evenly spaced, recycled HDPE slats**].

L. Plastic Facing Surrounds: Molded LMDPE shape.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
   a. Landscape Forms: Rosa Planter.
   b. Approved substitution.
2. Overall Height: 23 inches.
3. Overall Width: 36 inch diameter.
4. Capacity: 39 gallons.
5. Color: As selected by Architect from manufacturer's full range.

M. Precast Concrete Facing Surrounds: Decorative precast concrete units using dry-cast method.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
   a. Classic Garden Ornaments, Ltd.: LS 9310 Glencoe 34 [**24**] [**42**] with Round Base 16 [**13**] [**19**].
   b. Approved substitution.
2. Overall Height: 18 inches.
3. Overall Width: 34 inch diameter.
4. Base: 16 [**13**] [**19**] inch diameter.
5. Drainage: Manufacturer's standard 2 inch diameter, stainless steel.
6. Color: As selected by Architect from manufacturer's full range.

N. Cast Stone Facing Surrounds: Decorative concrete units using dry-cast method.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
   a. Classic Garden Ornaments, Ltd.: LS 9300 Riverside 45 Bowl Base].
   b. Approved substitution.
2. Overall Height: 20.5 inches.
3. Overall Width: 45 inch diameter.
4. Base: 24 inch square.
5. Drainage: Manufacturer's standard 2 inch diameter, stainless steel.
6. Color: As selected by Architect from manufacturer's full range.

O. Support Frames: [**Steel**] [**Galvanized steel**]; welded.

P. Planter Shape and Form: [**Round cylinder**] [**Round cylinder with tapered funnel top**] [**Round, tapered column**] [**Square column**] [**Rectangular column**] [**As indicated**].

Q. Style: [**To match benches**] [**As indicated by manufacturer's designation**].

R. Overall Height: As indicated.

S. Overall [**Diameter**] [**Width**]: As indicated.

T. Overall Depth: As indicated.

U. Weight: <Insert weight>.

V. Inner Container: [**Aluminum**] [**Galvanized-steel sheet**] [**Fiberglass**] [**Rigid plastic**] container[**with drain holes**].

W. Capacity: Not less than [**22 gal.**] [**28 gal.**] [**30 gal.**] [**32 gal.**] [**40 gal.**] [**55 gal.**].

X. Installation Method: [**Freestanding**] [**Freestanding with weighted base**] [**Anchored to substrate indicated on Drawings**] [**Wall mounted**] [**Post mounted**] [**Mounted on elevated leg angles anchored at finished grade to substrate indicated on Drawings**] [**Mounted on elevated leg angles anchored below finished grade to substrate indicated on Drawings**] [**As indicated on Drawings**].

1. Post Mount: [**Color-coated steel pipe; color to match receptacle**] [**Galvanized-steel pipe**] [**Wood**]; for mounting [**1**] [**2**] [**3**] planter(s).

Y. Aluminum Finish: Color coated.
1. Color: As selected by Architect from manufacturer's full range.

Z. Steel Finish: [**Galvanized and**] [**color**] [**PVC-color**] coated.
1. Color: As selected by Architect from manufacturer's full range.

AA. Stainless Steel Finish: ASTM A480, No. 6.

BB. Wood Finish: [**Unfinished**] [**Factory-applied transparent finish**] [**Factory-applied stained and transparent finish**].
1. Stain: <**Insert stain type and color**>.

CC. [**Fiberglass**] [**HDPE**] Color: As selected by Architect from manufacturer's full range.
1. Finish: [**Smooth**] [**Textured**].

2.6 BOLLARDS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide <**Insert Product**> by <**Insert Manufacture**> or comparable product by one of the following:
1. Canterbury International.
2. Columbia Cascade Company.
3. Creative Pipe, Inc.
4. DuMor Inc.
5. fermob
6. Fibrex Group Inc. (The).
7. Forms+Surfaces.
8. Huntco Supply, LLC.
9. Landscape Forms.
10. mmcité 7 LLC
11. Neenah Foundry Company.
12. Ore Incorporated.
13. Recreation Creations, Inc.
14. Sitecraft.
15. Smith & Hawken, Ltd.
16. SportsPlay Equipment, Inc.
17. Tournesol Siteworks, LLC.
18. Urban Accessories, Inc.
19. Approved substitution.

C. Bollard Construction:
1. [**Pipe**] [**Tubing**] [**Cast Iron**] OD: Not less than 4-1/2 inches[**, fluted**].
   a. Steel: [**Schedule 40**] [**Schedule 80**] pipe.
   b. Aluminum: [**Extruded pipe and tubes**] [**Castings**].
   c. Stainless Steel: [**Tubes**] [**Pipe**].
   d. Cast Iron: [**Tapered**] [**As indicated**].
2. [**Round**] [**Square**] Wood: [**Cedar**], [**8 inches square**] [**10 inches in diameter**].
3. Style: [**Manufacturer's standard**] [**Chamfered top**] [**Dome top**] [**Ornamental cap**].
4. Overall Height: As indicated.
5. Overall Width: As indicated.
6. Overall Depth: As indicated.
7. Accessories: Eye bolts.

8. Installation Method: [**Surface flange anchored at finished grade to substrate indicated**] [**Surface flange anchored below finished grade to substrate indicated**] [**Cast in concrete**] [**Bolted to cast-in anchor bolts**] [**As indicated**].

D. Aluminum Finish: [**Mill finish**] [**Color coated**].
1. Color: As selected by Architect from manufacturer's full range.

E. Steel Finish: [**Galvanized**] [**Color coated**].
1. Color: As selected by Architect from manufacturer's full range.

F. Cast-Iron Finish: [Manufacturer's standard] [Galvanized] [Color coated].
1. Color: As selected by Architect from manufacturer's full range.

G. Stainless Steel Finish: ASTM A480, No. 4.

H. Wood Finish: [**Unfinished**] [**Manufacturer's standard finish**].

2.7 MATERIALS

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
1. Recycled Content of Aluminum Products: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 20 percent.
2. Rolled or Cold-Finished Bars, Rods, and Wire: ASTM B211.
3. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B221.
4. Structural Pipe and Tube: ASTM B429.
5. Sheet and Plate: ASTM B209.
6. Castings: ASTM B26.

B. Steel and Iron: Free of surface blemishes and complying with the following:
1. Recycled Content of Steel Products: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than 65 percent.
2. Plates, Shapes, and Bars: ASTM A36.
3. Steel Pipe: Standard-weight steel pipe complying with ASTM A53, or electric-resistance-welded pipe complying with ASTM A135.
4. Tubing: Cold-formed steel tubing complying with ASTM A500.
5. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513, or steel tubing fabricated from steel complying with ASTM A1011 and complying with dimensional tolerances in ASTM A500; zinc coated internally and externally.
6. Sheet: Commercial steel sheet complying with ASTM A1011.
7. Perforated Metal: From steel sheet not less than [**0.075 inch**] [**0.090 inch**] [**0.120 inch**] nominal thickness; manufacturer's standard perforation pattern.
8. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
9. Malleable-Iron Castings: ASTM A47, grade as recommended by fabricator for type of use intended.
10. Gray-Iron Castings: ASTM A48, Class 200.

C. Stainless Steel: Free of surface blemishes and complying with the following:
1. Sheet, Strip, Plate, and Flat Bars: ASTM A240 or ASTM A666.
2. Pipe: Schedule 40 steel pipe complying with ASTM A312.
3. Tubing: ASTM A554.

D. Wood: Surfaced smooth on 4 sides with eased edges; kiln dried, free of knots, solid stock of species indicated.
1. Wood Species: Manufacturer's standard.

a. Douglas Fir: Clear Grade, vertical grain.
b. Pine: Southern pine; No. 2 or better[**; preservative treated, kiln dried after treatment**].
c. [**Eastern White**] [**Red**] [**Yellow**] Cedar: Select Grade or better.
d. Redwood: [**Clear all heart**] [**Construction heart or better**], free-of-heart center.
e. Teak (Tectona Grandis): Clear Grade.

E. Certified Wood: Certify wood products as "FSC Pure" in accordance with FSC STD-01-001 and FSC STD-40-004.
1. Finish: Manufacturer's standard [**stain**] [**and**] [**transparent sealer**] [**transparent wood-preservative treatment and sealer**].

F. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.

G. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
1. Polyethylene: Fabricated from virgin plastic HDPE resin.
2. Polyethylene with Recycled Content: Fabricated from HDPE and other resins with postconsumer recycled content plus 1/2 of preconsumer recycled content not less than <**Insert value**> percent.

H. Anchors, Fasteners, Fittings, and Hardware: Stainless steel [**Galvanized steel**] [**Zinc-plated steel**] [**Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials**]; commercial quality[, **tamperproof, vandal and theft resistant**] [, **concealed, recessed, and capped or plugged**].
1. Angle Anchors: For inconspicuously bolting legs of site furnishings to [**on**] [**below**]-grade substrate; [**1 per leg**] [**extent as indicated**].
2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; [**2 per unit**] [**extent as indicated on Drawings**].

I. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107; recommended in writing by manufacturer, for exterior applications.

J. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

K. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil thick.
2. Hot-Dip Galvanizing: According to ASTM A123, ASTM A153, or ASTM A924.

2.8 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure-treat wood according to AWPA U1, Use Category UC3b, and the following:
1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.

2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.9 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; surfaces smooth, free of burrs, barbs, splinters, and sharpness; edges and ends rolled, rounded, or capped.

F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in field.

2.10 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within range of approved Samples and are assembled or installed to minimize contrast.

2.11 ALUMINUM FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.12 STEEL AND GALVANIZED-STEEL FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.13 IRON FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.14 STAINLESS STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
   1. Run directional finishes with long dimension of each piece.
   2. Directional Satin Finish: ASTM A480, No 4.
   3. Dull Satin Finish: ASTM A480, No. 6.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of Work.

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

3.2 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and [**securely anchored**] [**positioned**] at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with [**nonshrink, nonmetallic grout**] [**or**] [**anchoring cement**], mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with [**nonshrink, nonmetallic grout**] [**or**] [**anchoring cement**], mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION 323300

SECTION 323313

SITE BICYCLE RACKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Exterior bicycle racks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Verification: For each type of exposed finish, not less than the following sizes:
   1. Linear Components: Not less than 6 inches long.
   2. Approved samples may be incorporated into Work.

C. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For bicycle racks to include in maintenance manuals.

1.4 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.

B. Security Nut Tools: Tools for operating security nuts.
   1. Type: Bit for drill or power screwdriver and hand driver with handle.
   2. Quantity: Minimum of 2 of each type of tool required.
   3. Delivery: Submit tools directly to Owner.

1.5 WARRANTY

A. Materials Warranty: Manufacturer agrees to repair or replace bicycle parking products that fail in materials or workmanship within specified warranty period.
   1. Warranty Periods: Starting from date of Substantial Completion:
      a. Materials and Workmanship: 1 year.

PART 2 - PRODUCTS

2.1 EXTERIOR BICYCLE RACKS

A. Bicycle Rack Construction: Surface-mounted rails designed to accept multiple quantities of manufacturer's inverted U-shaped mounting racks.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
      a. Sportworks Northwest, Inc.: Standard Mounting Rails.
      b. Approved substitution.
   2. Frame: Extruded aluminum.
      a. Size: Not less than 5.6 inches wide by 1.3 inches high.
      b. Length: Determined by capacity required for each set.
      c. Capacities:
         1) 6 Bikes: 66.1 inches.

2) 8 Bikes: 93.6 inches.
3) 10 Bikes: 121/1 inches.

3. End Caps: Plastic-injection-molded plastic pieces secured into each end of mounting rail.
4. Installation Method: Surface flange anchored at finished grade to substrate indicated.

B. Aluminum Finish: Clear anodized.

2.2 MATERIALS

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
1. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B221.

B. Anchors, Fasteners, Fittings, and Hardware: Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality, tamperproof, vandal and theft resistant.

C. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107.

2.3 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

D. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of Work.

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

3.2 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of racks and lockers where required.

B. Comply with Association of Pedestrian and Bicycle Professionals (APBP) recommendations for location and spacing.

C. Install bicycle mounting rails level and securely anchored at locations indicated on Drawings, and ready to receive installation of U-shaped mounting racks.

END OF SECTION 323313

SECTION 328400

PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Piping.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.

1.2 DEFINITIONS

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. ET Controllers: EvapoTranspiration Controllers. Irrigation controllers which use some method of weather based adjustment of irrigation. These adjusting methods include use of historical monthly averages of ET; broadcasting of ET measurements; or use of on-site sensors to track ET.

D. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

E. 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.

1.3 ACTION SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

D. Sustainable Design Submittals:
1. Irrigation Submetering: Provide manufacturer cut sheets for irrigation metering equipment.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions such as signs and light standards.

B. Qualification Data: For qualified Installer.

C. Zoning Chart: Show each irrigation zone and its control valve.

D. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [**sprinklers**] [**controllers**] [**and**] [**automatic control valves**] to include in operation and maintenance manuals.

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. Spray Sprinklers: Equal to 5 percent of amount installed for each type and size indicated, but no fewer than 10 units.
   2. Bubblers: Equal to 5 percent of amount installed for each type indicated, but no fewer than 10 units.
   3. Drip-Tube System Tubing: Equal to 5 percent of total length installed for each type and size indicated, but not less than 500 feet.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers that include a certified irrigation designer qualified by The Irrigation Association.

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

1.8 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.9 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Owner no fewer than 2 days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE CRITERIA

A. Irrigation zone control shall be automatic operation with controller and automatic control valves.

B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.

C. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
   1. Irrigation Main Piping: 200 psig.
   2. Circuit Piping: 150 psig.

2.2 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Galvanized-Steel Pipe: ASTM A53, Standard Weight, Type E, Grade B.
   1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53 or ASTM A106, Standard Weight, seamless-steel pipe with threaded ends.
   2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
   3. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
   4. Cast-Iron Flanges: ASME B16.1, Class 125.

C. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.
   1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      a. Gaskets: AWWA C111, rubber.

E. Soft Copper Tube: ASTM B88, Type L, water tube, annealed temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
   3. 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.

F. Hard Copper Tube: ASTM B88, Type L, and ASTM B88, Type M, water tube, drawn temper.
   1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
   2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
   3. 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.

G. PE Pipe with Controlled ID: ASTM F771, PE 3408 compound; SIDR 11.5 and SIDR 15.
   1. Insert Fittings for PE Pipe: ASTM D2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.

H. PE Pipe with Controlled OD: ASTM F771, PE 3408 compound, SDR 11.
   1. PE Butt, Heat-Fusion Fittings: ASTM D3261.
   2. PE Socket-Type Fittings: ASTM D2683.

I. PE Pressure Pipe: AWWA C906, with DR of 7.3, 9, or 9.3 and PE compound number required to give pressure rating not less than 160 psig.
   1. PE Butt, Heat-Fusion Fittings: ASTM D3261.

2. PE Socket-Type Fittings: ASTM D2683.

J. PVC Pipe: ASTM D1785, PVC 1120 compound, Schedules 40 and 80.
1. PVC Socket Fittings: ASTM D2466, Schedules 40 and 80.
2. PVC Threaded Fittings: ASTM D2464, Schedule 80.
3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

K. PVC Pipe, Pressure Rated: ASTM D2241, PVC 1120 compound, SDR 21.
1. PVC Socket Fittings: ASTM D2467, Schedule 80.
2. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick unless otherwise indicated; full-face or ring type unless otherwise indicated.

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

C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

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

E. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 ENCASEMENT FOR PIPING

A. Standard: ASTM A674 or AWWA C105.

B. Form: Sheet or tube.

C. Material: LLDPE film of 0.008-inch minimum thickness or high-density, cross-laminated PE film of 0.004-inch minimum thickness.

D. Color: Black.

2.5 MANUAL VALVES

A. Curb Valves:
1. Description:
a. Standard: AWWA C800.
b. NPS 1 and Smaller Pressure Rating: 100 psig minimum.
c. NPS 1-1/4 to NPS 2 Pressure Rating: 80 psig minimum.
d. Body Material: Brass or bronze with ball or ground-key plug.
e. End Connections: Matching piping.
f. Stem: With wide-tee head.

B. Curb-Valve Casing:
1. Standard: Similar to AWWA M44 for cast-iron valve casings.
2. Top Section: Telescoping, of length required for depth of burial of curb valve.
3. Barrel: Approximately 3-inch diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.

6. Base Support: Concrete collar.

C. Shutoff Rods for Curb-Valve Casings: Furnish 1 steel, tee-handle shutoff rod(s) with 1 pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve for Project.

D. Brass Ball Valves:
1. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full or regular, but not reduced.

E. Bronze Ball Valves:
1. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full or regular, but not reduced.

F. Iron Ball Valves:
1. Description:
a. Standard: MSS SP-72.
b. CWP Rating: 200 psig.
c. Body Design: Split body.
d. Body Material: ASTM A126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

G. Plastic Ball Valves:
1. Description:
a. Standard: MSS SP-122.
b. Pressure Rating: 125 psig minimum.
c. Body Material: PVC.
d. Type: Union.
e. End Connections: Socket or threaded.
f. Port: Full.

H. Bronze Gate Valves:
1. Description:
a. Standard: MSS SP-80, Type 2.
b. Class: 125.

c. CWP Rating: 200 psig.
d. Body Material: ASTM B62 bronze with integral seat and screw-in bonnet.
e. Ends: Threaded or solder joint.
f. Stem: Bronze, nonrising.
g. Disc: Solid wedge; bronze.
h. Packing: Asbestos free.
i. Handwheel: Malleable iron, bronze, or aluminum.

I. Iron Gate Valves, Resilient Seated:
1. Description:
a. Standard: AWWA C509.
b. Pressure Rating: [**200 psig**] [**250 psig**] minimum.
c. Body Material: Ductile or gray iron with bronze trim.
d. End Connections: Mechanical joint or push-on joint.
e. Interior Coating: Comply with AWWA C550.
f. Body Design: Nonrising stem.
g. Operator: Stem nut.
h. Disc: Solid wedge with resilient coating.

J. Iron Gate Valve Casings:
1. Standard: AWWA M44 for cast-iron valve casings.
2. Top Section: Adjustable extension of length required for depth of burial of valve.
3. Barrel: Approximately 5-inch diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.
6. Base Support: Concrete collar[**or wood frame**].

K. Operating Wrenches for Iron Gate Valve Casings: Furnish 1 steel, tee-handle operating wrench(es) with 1 pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut for Project.

L. Iron Gate Valves, NRS:
1. Description:
a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: All bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

M. Iron Gate Valves, OS&Y:
1. Description:
a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: All bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

2.6 PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Description:
a. Standard: ASSE 1003.

b. Body Material: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
c. Pressure Rating: Initial pressure of 150 psig.
d. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.7 AUTOMATIC CONTROL VALVES

A. Plastic, Automatic Control Valves:
1. Per Plans.
2. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.8 AUTOMATIC DRAIN VALVES

A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig.

2.9 TRANSITION FITTINGS

A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings:
1. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Plastic-to-Metal Transition Fittings:
1. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket[**or threaded**] end.

D. Plastic-to-Metal Transition Unions:
1. Description: MSS SP-107, PVC four-part union. Include 1 brass or stainless-steel threaded end, 1 solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

2.10 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Description: Factory-fabricated union, NPS 2 and smaller.
a. Pressure Rating: 150 psig minimum at 180 deg F.
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:
1. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 and larger.
a. Pressure Rating: 150 psig minimum.
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
1. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 and larger.
a. Pressure Rating: 150 psig minimum.
b. Gasket: Neoprene or phenolic.
c. Bolt Sleeves: Phenolic or polyethylene.

d. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:
1. Description: Galvanized-steel coupling.
a. Pressure Rating: 300 psig at 225 deg F.
b. End Connections: Female threaded.
c. Lining: Inert and noncorrosive, thermoplastic lining.

F. Dielectric Nipples:
1. Description: Electroplated steel nipple complying with ASTM F1545.
a. Pressure Rating: 300 psig at 225 deg F.
b. End Connections: Male threaded or grooved.
c. Lining: Inert and noncorrosive, propylene.

2.11 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.

B. Pressure Gages: ASME B40.1. Include 4-1/2 inch diameter dial, dial range of 2 times system operating pressure, and bottom outlet.

2.12 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.

B. Plastic, Surface Spray Sprinklers:
1. Per Plans.
2. Description:
a. Body Material and Flange: ABS.
b. Pattern: Fixed, with flow adjustment.
3. Capacities and Characteristics:
a. Nozzle: ABS.
b. Flow: Per Plans
c. Arc: Full Half Quarter circle.
d. Radius: Per Plans.

C. Plastic, Surface, Pop-up Spray Sprinklers:
1. Per Plans.
2. Description:
a. Body Material and Flange: ABS.
b. Pattern: Fixed, with flow adjustment.
3. Capacities and Characteristics:
a. Pop-up Height: [**4 inches**] [**1-1/4 or 1-1/2 inches**] [**1-3/4 or 2 inches**].
b. Nozzle: [**ABS**] [**Brass**].
c. Flow: <**Insert gpm**>.
d. Arc: [**Full**] [**Half**] [**Quarter**] circle.
e. Radius: <**Insert feet**>.
f. Inlet: [**NPS 1/2**] [**NPS 1/2 or NPS 3/4**] [**NPS 3/4**].

D. Plastic, Pop-up Spray Sprinklers:
1. Per Plans.
2. Description:
a. Body Material: ABS.
b. Nozzle: [**ABS**] [**Brass**].
c. Retraction Spring: Stainless steel.

d. Internal Parts: Corrosion resistant.
e. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:
   a. Nozzle: ABS.
   b. Flow: Per Plans.
   c. Pop-up Height: 4 inches aboveground to nozzle.
   d. Arc: Full Half Quarter circle.
   e. Radius: Per Plans.

2.13 QUICK COUPLERS

A. Per Plans.

B. Description: Factory-fabricated, bronze or brass, 2-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.
   1. Locking-Top Option: Vandal-resistant locking feature. Include 2 matching key(s).

2.14 DRIP IRRIGATION SPECIALTIES

A. Per Plans.

B. Drip Tubes with Direct-Attached Emitters:
   1. Tubing: Flexible PE or PVC with plugged end.
   2. Emitters: Devices to deliver water at approximately 20 psig.
      a. Body Material: PE or vinyl, with flow control.
      b. Mounting: Inserted into tubing at set intervals.
   3. Capacities and Characteristics:
      a. Tubing Size: Per Plans..
      b. Length: Per Plans.
      c. Emitter Spacing: Per Plans.
      d. Emitter Flow: Per Plans.

C. Off-Ground Supports: Plastic stakes.

D. Application Pressure Regulators: Brass or plastic housing, NPS 3/4, with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig.

E. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.

F. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

G. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.15 CONTROLLERS

A. Per Plans.

B. Description:
   1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
   2. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and 2 matching keys.
      a. Body Material: Molded plastic.
      b. Mounting: Surface type for wall.
   3. Control Transformer: 24-V secondary, with primary fuse.

4. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate 2 or more times daily.
   a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
   b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
   c. Surge Protection: Metal-oxide-varistor type on each station and primary power.
5. Moisture Sensor: Adjustable from 1 to 7 days, to shut off water flow during rain.
6. Smart Controllers: Use ET, tested in accordance with IA SWAT Climatological Based Controllers 8th Draft Testing Protocol and compliant with ASHRAE Standard 189.1.
7. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
   a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
   b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
   c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
8. Concrete Base: Reinforced precast concrete not less than 36 by 24 by 4 inches thick, and 6 inches greater in each direction than overall dimensions of controller. Include opening for wiring.

2.16 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:
   1. Per Plans.
   2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
      a. Size: As required for valves and service.
      b. Shape: Rectangular.
      c. Sidewall Material: PE, ABS, or FRP.
      d. Cover Material: PE, ABS, or FRP.
         1) Lettering: " IRRIGATION."
      e. Color: Black

B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minimum to 3 inches maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

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

B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.

C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches, to 12 inches below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

D. Provide minimum cover over top of underground piping according to the following:
   1. Irrigation Main Piping: Minimum depth of 36 inches below finished grade, or not less than 18 inches below average local frost depth, whichever is deeper.
   2. Circuit Piping: 12 inches.
   3. Drain Piping: 12 inches.

4. Sleeves: 24 inches.

3.2 PREPARATION

A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

3.3 INSTALLATION OF PIPING

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

E. Install fittings for changes in direction and branch connections.

F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.

G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 or larger pipe connection.

H. Install underground thermoplastic piping according to ASTM D2774.

I. Install expansion loops in control-valve boxes for plastic piping.

J. Lay piping on solid subbase, uniformly sloped without humps or depressions.

K. Install ductile-iron piping according to AWWA C600.

L. Install PVC piping in dry weather when temperature is above 40 deg F. Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.

M. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.

N. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

O. Install piping in sleeves under parking lots, roadways, and sidewalks.

P. Install sleeves made of Schedule 40 PVC pipe and socket fittings, and solvent-cemented joints.

Q. Install transition fittings for plastic-to-metal pipe connections according to the following:
   1. Underground Piping:
      a. NPS 1-1/2 and Smaller: Plastic-to-metal transition fittings.
      b. NPS 2 and Larger: AWWA transition couplings.
   2. Aboveground Piping:
      a. NPS 2 and Smaller: Plastic-to-metal transition fittings.
      b. NPS 2 and Larger: Use dielectric flange kits with one plastic flange.

R. Install dielectric fittings for dissimilar-metal pipe connections according to the following:
   1. Underground Piping:
      a. NPS 2 and Smaller: Dielectric coupling or dielectric nipple.
      b. NPS 2-1/2 and Larger: Prohibited except in control-valve box.
   2. Aboveground Piping:

a. NPS 2 and Smaller: Dielectric union.
b. NPS 2-1/2 to NPS 4: Dielectric flange.
c. NPS 5 and Larger: Dielectric flange kit.

3. Piping in Control-Valve Boxes:
   a. NPS 2 and Smaller: Dielectric union.
   b. NPS 2-1/2 to NPS 4: Dielectric flange.
   c. NPS 5 and Larger: Dielectric flange kit.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.

F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.

G. Copper-Tubing Soldered Joints: Apply ASTM B813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.

H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

I. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.
   1. Plain-End PE Pipe and Fittings: Use butt fusion.
   2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

J. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Pressure Piping: Join schedule number, ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
   3. PVC Nonpressure Piping: Join according to ASTM D2855.

3.5 VALVE INSTALLATION

A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.

B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.
   1. Install valves and PVC pipe with restrained, gasketed joints.

C. Aboveground Valves: Install as components of connected piping system.

D. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves. Install full-size valved bypass.

E. Throttling Valves: Install in underground piping in boxes for automatic control valves.

F. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers at manufacturer's recommended heights.

C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.7 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install freestanding emitters on pipe riser to mounting height indicated.

B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.

C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.

D. Install drip tubes with direct-attached emitters on ground.

E. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.

F. Install off-ground supports of length required for indicated mounted height of device.

G. Install application pressure regulators and filter units in piping near device being protected, and in control-valve boxes.

H. Install air relief valves and vacuum relief valves in piping, and in control-valve boxes.

3.8 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install interior controllers on [**floor**] [**concrete bases**] [**wall**].
   1. Place and secure anchorage devices. Use 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.

B. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.
   1. Place and secure anchorage devices. Use 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.

C. Install control cable in same trench as irrigation piping and at least 2 inches below [**or beside**] piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.9 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Section for Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

C. Connect wiring between controllers and automatic control valves.

3.10 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Division 22 Section for Identification for Plumbing Piping and Equipment.

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
   1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Division 31 Section for Earth Moving for warning tapes.

3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Any irrigation product will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 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. Verify that controllers are installed and connected according to Contract Documents.
   3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.13 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.

3.14 CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.15 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain [**automatic control valves**] [**and**] [**controllers**].

3.16 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.

C. Aboveground irrigation main piping, NPS 4 and smaller, shall be [**one of**] the following:
1. Type L or Type M hard copper tube, wrought- or cast-copper fittings, and soldered joints.
2. Schedule 40, PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
3. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

D. Aboveground irrigation main piping, NPS 5 and larger, shall be one of the following:
1. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
2. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

E. Underground irrigation main piping, NPS 4 and smaller, shall be [**one of**] the following:
1. NPS 3 and NPS 4 ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
2. NPS 3 and NPS 4 ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
3. Type L soft copper tube, wrought-copper fittings, and brazed joints.
4. NPS 4 PE pressure pipe; PE butt, heat-fusion or socket-type fittings; and heat-fusion joints.
5. Schedule 40, PVC pipe and socket fittings, and solvent-cemented joints.
6. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
7. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

F. Underground irrigation main piping, NPS 5 and larger, shall be [**one of**] the following:
1. NPS 6 and larger ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
2. NPS 6 and larger ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
3. PE pressure pipe; PE butt, heat-fusion fittings; and heat-fusion joints.
4. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
5. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

G. Circuit piping, NPS 2 and smaller, shall be [**one of**] the following:
1. SIDR 7, SIDR 9, PE, controlled ID pipe; insert fittings for PE pipe; and fastener joints.
2. DR 9, DR 11, PE, controlled OD pipe; PE butt, heat-fusion, or PE socket-type fittings; and heat-fusion joints.
3. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.

4. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

H. Circuit piping, NPS 2-1/2 to NPS 4, shall be [**one of**] the following:
1. SIDR 7, SIDR 9, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
2. DR 9, DR 11, PE, controlled OD pipe; PE socket or butt-fusion fittings; and heat-fusion joints. NPS 3 pipe and fittings if NPS 2-1/2 pipe and fittings are not available.
3. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
4. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

I. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.
1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.

J. Risers to Aboveground Sprinklers and Specialties: Type L or Type M hard copper tube, wrought-copper fittings, and soldered joints.

K. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

L. Drain piping shall be [**one of**] the following:
1. SIDR 9, 11.5, or 15, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
3. SDR 21, 26, or 32.5, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

END OF SECTION 328400

SECTION 329113

SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Planting soils and layered soil assemblies specified by composition of mixes.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct meeting at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, include the following:
   1. Recommendations for application and use.
   2. Test data substantiating that products comply with requirements.
   3. Sieve analyses for aggregate materials.
   4. Material Certificates: For each type of soil amendment and fertilizer before delivery to site, according to the following:
      a. Manufacturer's qualified testing agency's certified analysis of standard products.
      b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
      c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Sustainable Design Submittals:
   1. Environmental Product Declaration (EPD): For each product.

C. Samples: For each bulk-supplied material, 1 quart volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with experience and capability to conduct testing indicated; and that specializes in types of tests to be performed.
   1. Laboratories: Subject to compliance with requirements, provide testing by the following:
      a. Soiltest Farm Consultants, Inc. 2925 Driggs Dr., Moses Lake, WA 98837 (509)765-1622 or (800)764-1622 FAX (509)765-0314, www.soiltestlab.com
      b. Or approved equal.
   2. Multiple Laboratories: At Contractor's option, Work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.6 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Owner will engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil.
   1. Notify Architect 7 days in advance of dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
   1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.7 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this Article.

B. Sample Collection and Labeling: Have samples taken and labeled by soil scientist (CPSS) certified by SSSA, soil classifier (CPSC) certified by SSSA, soil scientist (RPSS) registered by National Society of Consulting Soil Scientists or state-certified, -licensed, or -registered soil scientist under the direction of the testing agency.
   1. Number and Location of Samples: Minimum of 8 representative soil samples from varied locations for each soil to be used or amended for landscaping purposes.
   2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils."
   3. Division of Samples: Split each sample into 2, equal parts. Send half to testing agency and half to Owner for its records.
   4. Labeling: Label each sample with date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.8 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:
   1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
      a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
      b. Hydrometer Method: Report percentages of sand, silt, and clay.
   2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85 percent compaction according to ASTM D698 (Standard Proctor).

C. Chemical Testing:
   1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
   2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."

3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of [SSSA NAPT WERA-103], including the following:
1. Percentage of organic matter.
2. CEC, calcium percent of CEC, and magnesium percent of CEC.
3. Soil reaction (acidity/alkalinity pH value).
4. Buffered acidity or alkalinity.
5. Nitrogen ppm.
6. Phosphorous ppm.
7. Potassium ppm.
8. Manganese ppm.
9. Manganese-availability ppm.
10. Zinc ppm.
11. Zinc availability ppm.
12. Copper ppm.
13. Sodium ppm and sodium absorption ratio.
14. Soluble-salts ppm.
15. Presence and quantities of problem materials including salts and metals cited in Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

F. Recommendations: Based on test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1,000 sq. ft. for 6 inch depth of soil.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1,000 sq. ft. for 6 inch depth of soil.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 PLANTING SOILS SPECIFIED BY COMPOSITION

A. General: Soil amendments, fertilizers, and rates of application specified in this Article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Planting Areas: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site; modified to produce viable planting soil for trees, shrubs, and groundcovers. Blend existing, on-site surface soil with soil amendments as directed by the Landscape Architect in consultation with the soil testing laboratory.

C. Natural Lawn Areas: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site; modified to produce viable planting soil for a seeded lawn. Blend existing, on-site surface soil with the following soil amendments as directed by the Landscape Architect in consultation with the soil testing laboratory.

2.2 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.
   2. Class: O, with a minimum of 95 percent passing through a No. 8 sieve and a minimum of 55 percent passing through a No. 60 sieve.
   3. Form: Provide lime in form of ground dolomitic limestone, calcitic limestone, or mollusk shells.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
   1. Feedstock: Limited to leaves May include animal waste.
   2. Reaction: pH of 5.5 to 8.
   3. Soluble-Salt Concentration: Less than 4 dS/m.
   4. Moisture Content: 35 to 55 percent by weight.
   5. Organic-Matter Content: 50 to 60 percent of dry weight.
   6. Particle Size: Minimum of 98 percent passing through a 1 inch sieve.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2 inch sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a 1/2 inch sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1,100 to 2,000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
   1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of [**20**] [**33**] [**50**] percent available phosphoric acid.

B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: 1 lb/1,000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

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

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 3 inch sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 12 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.

C. Mixing: Spread unamended soil to total depth of 12 inches, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
   1. Amendments: Apply soil amendments evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
      a. Mix lime and sulfur with dry soil before mixing fertilizer.
      b. Mix fertilizer with planting soil no more than 7 days before planting.
   2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 12 inches in loose depth for material compacted by compaction equipment, and not more than 6 inches in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 and tested in-place.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

F.

3.4 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of of 12 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Apply soil amendments and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.
   1. Mix lime and sulfur with dry soil before mixing fertilizer.
   2. Mix fertilizer with planting soil no more than 7 days before planting.

D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests:
   1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. Space tests at no less than one for each 2,000 sq. ft. of in-place soil or part thereof.

C. Soil will be considered defective if it does not pass tests and inspections.

D. Prepare test reports.

E. Label each sample and test report with date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.6 PROTECTION

A. Protection Zone: Identify protection zones according to Section 015639 – Temporary Tree and Plant Protection.

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Vehicle traffic.
   4. Foot traffic.
   5. Erection of sheds or structures.
   6. Impoundment of water.
   7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove planting soil and contamination; restore subgrade as directed by Architect, and replace contaminated planting soil with new planting soil.

3.7 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and Work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
   1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329113

SECTION 329200

TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Seeding.
   2. Hydroseeding.
   3. Meadow grasses and wildflowers.
   4. Grass-paving materials.

1.2 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 – Soil Preparation and drawing designations for planting soils.

E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct meeting at Project site.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include year of production and date of packaging.

C. Product Certificates: For fertilizers, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required maintenance periods.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf and meadow establishment.

1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
2. Experience: [**3**] [**5**] years' experience in turf installation in addition to requirements in Section 014000 – Quality Requirements.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when Work is in progress.
4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the National Association of Landscape Professionals:
   a. Landscape Industry Certified Technician - Exterior.
   b. Landscape Industry Certified Lawn Care Manager.
   c. Landscape Industry Certified Lawn Care Technician.
5. Pesticide Applicator: State licensed, commercial.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

1.8 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
   1. Spring Planting: March - June.
   2. Fall Planting: September - November.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Grass-Seed Mix: Proprietary seed mix as follows:
   1. Products: Subject to compliance with requirements, provide the following or approved equal:
      a. JB Instant Lawn - Sun and Shade Mix.

2.2 MEADOW GRASSES AND WILDFLOWERS

A. Wildflower Seed: Fresh, clean, and dry new seed, of mixed species as follows:
   1. Meadow Mix consisting of:

a. Annual Wildflowers: 10% Seablush (Plectritis congesta), 8% Globe Gilia (Gilia capitata), 6% Farewell to Spring (Clarkia amoena), 5%Diamond Clarkia (Clarkia rhomboidea), 3% Wine Cup Clarkia (Clarkia purpurea)
b. Perennial Wildflowers: % Lewis Flax (Linum lewisii), 8%Self Heal (Prunella vulgaris), 6% Oregon Phacelia (Phacelia nemoralis), 5%Western Yarrow (Achillea millefolium), 4% Puget Sound Gumweed (Grindeliaintegrifolia), 4% Oregon Sunshine (Eriophyllum lanatum), 4% Canada Goldenrod(Solidago canadensis), 3% Meriwether Blanketflower (Gallardia aristata'Meriwether'), 2% Large Camas (Camassia leichtinii), 1% Large Flower Collomia(Collomia grandiflora), 1% Nettle Leaf Giant Hyssop (Agastache urticifolia),0.5% Riverbank Lupine (Lupinus rivularis), 0.5% Rose Checkermallow (Sidalceamalviflora), 0.5% Western Buttercup (Ranunculus occidentalis), 0.5% CommonCamas (Camassia quamash), 0.5% Bigleaf Lupine (Lupinus polyphyllus), 0.5%Meadow Checkermallow (Sidalcea campestris), 0.5% Showy Milkweed (Asclepias speciosa),0.5% Columbine (Aquilegia formosa)
c. Grasses: 5% Prairie Junegrass (Koeleriamacrantha), 3% Blue Wild Rye (Elymus glaucus), 3% Roemer's Fescue (Festucaromerii), 2% California Oatgrass (Danthonia californica), 2% California Brome(Bromus carinatus), 2% Tufted Hairgrass (Deschampsia ceaspitosa), 1% MeadowBarley (Horedum brachyantherum).

B. Seed Mix basis of Design: Rain Garden, Wildlife, and Farm Buffer – Seed Mix, by Northwest Meadowscapes.

2.3 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition:
a. 1 lb/1,000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
1. Composition:
a. 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
b. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.4 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1,100 to 2,000 percent, and containing no sand.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1 inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
1. Organic Matter Content: 50 to 60 percent of dry weight.

2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

E. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.5 GRASS-PAVING MATERIALS

A. Grass Paving: Cellular, nonbiodegradable plastic mats, designed to contain small areas of soil and enhance the ability of turf to support vehicular and pedestrian traffic, of manufacturer's standard nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Airfield Systems, LLC.
b. Grid Technologies, Inc.
c. Invisible Structures, Inc.
d. NDS Inc.
e. PermaTurf Co., Inc.
f. Presto Products Company.
g. RK Manufacturing, Inc.

B. Base Course: Sound crushed stone or gravel complying with ASTM D448 for Size No. 8.

C. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33 for fine aggregate.

D. Proprietary Growing Mix: As submitted and acceptable to Landscape Architect.

E. Sandy Loam Soil Mix: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33 for fine aggregate blended with planting soil. Use blend consisting of 2/3 sand and 1/3 planting soil.

F. Soil for Paving Fill: Planting soil.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of Work.
1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Suspend planting operations during periods of excessive soil moisture until moisture content reaches acceptable levels to attain required results.
3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
   1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
   2. Protect grade stakes set by others until directed to remove them.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 PREPARATION FOR GRASS-PAVING MATERIALS

A. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions.

B. Install base course and proprietary growing mix as recommended by paving-material manufacturer for site conditions and according to details indicated on Drawings. Compact according to paving-material manufacturer's written instructions.

C. Install paving mat and fasten according to paving-material manufacturer's written instructions.

D. Before planting, fill cells of paving mat with proprietary growing mix and compact according to manufacturer's written instructions.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.4 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.
   1. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
   2. Do not use wet seed or seed that is moldy or otherwise damaged.
   3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 5 to 8 lb/1,000 sq. ft. or per manufacturer’s recommendations.

C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.5 HYDROSEEDING

A. Hydroseeding: Mix specified seed, slow-release fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
   1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
   2. Spray-apply slurry uniformly to areas to be seeded in a 1-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1,500-lb/acre dry weight, and seed component is deposited at not less than specified seed-sowing rate.
   3. Spray-apply slurry uniformly to all areas to be seeded in a 2-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight,

and seed component is deposited at not less than specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1,000 lb/acre.

3.6 TURF MAINTENANCE

A. General: 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.
   1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
   2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
   3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

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.
   1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

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. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

D. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.
   1. Use fertilizer that provides actual nitrogen of at least 1 lb/1,000 sq. ft. to turf area.

3.7 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:
   1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
   2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
   3. Satisfactory Plugged Turf: At end of maintenance period, required number of plugs have been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
   4. Satisfactory Sprigged Turf: At end of maintenance period, required number of sprigs have been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.8 MEADOW

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.

1. Before sowing, mix seed with seed carrier at a ratio of not less than 2 parts seed carrier to 1 part seed.
2. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
3. Do not use wet seed or seed that is moldy or otherwise damaged.

B. Sow seed at a total rate of 5 oz./1,000 sq. ft.

C. Brush seed into top 1/16 inch of soil, roll lightly, and water with fine spray.

D. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

E. Water newly planted areas and keep moist until meadow is established.

3.9 MEADOW MAINTENANCE

A. Maintain and establish meadow by watering, weeding, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable meadow. Roll, regrade, and replant bare or eroded areas and remulch. Provide materials and installation same as those used in original installation.
1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and meadow damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Apply treatments as required to keep meadow and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize use of pesticides and reduce hazards.

B. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.
1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water meadow with fine spray at a minimum rate of 1/2 inch per week for 8 weeks after planting unless rainfall precipitation is adequate.

3.10 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf Work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Remove nondegradable erosion-control measures after grass establishment period.

3.11 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
1. Seeded Turf: 60 days from date of planting completion.
    a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

B. Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Meadow Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable meadow is established, but for not less than maintenance period below.
   1. Maintenance Period: 40 days from date of planting completion.

END OF SECTION 329200

SECTION 329300

PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Plants.
   2. Tree stabilization.

1.2 UNIT PRICES

A. Work of this Section is affected by unit prices specified in Section 012200 – Unit Prices.

B. Unit prices apply to authorized Work covered by quantity allowances.

C. Unit prices apply to additions to and deletions from Work as authorized by Change Orders.

1.3 DEFINITIONS

A. Backfill: Earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with root flare visible at surface of the as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 – Soil Preparation for Drawing designations for planting soils.

L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where stem or trunk broadens to form roots; area of transition between root system and stem or trunk.

N. Stem Girdling Roots: Roots that encircle stems (trunks) of trees below soil surface.

O. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
    a. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

B. Preinstallation Meetings: Conduct meeting at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of 3 photographs showing average plant, best quality plant, and worst quality plant to be furnished. Identify each photograph with full scientific name of plant, plant size, and name of growing nursery.

B. Samples for Verification: For each of the following:
1. Trees and Shrubs: 3 Samples of each variety and size delivered to site for review. Maintain approved Samples on-site as a standard for comparison.
2. Organic Compost Mulch: 1 pint volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished. Provide an accurate representation of color, texture, and organic makeup.
3. Weed Control Barrier: 12 by 12 inches.
4. Proprietary Root-Ball-Stabilization Device: 1 unit.
5. Root Barrier: Width of panel by 12 inches.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
1. Manufacturer's certified analysis of standard products.

2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
2. Experience: [**3**] [**5**] years' experience in landscape installation in addition to requirements in Section 014000 – Quality Requirements.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when Work is in progress.
4. Personnel Certifications: Installer's field supervisor shall have certification in 1 of the following categories from the National Association of Landscape Professionals:
   a. Landscape Industry Certified Technician - Exterior.
   b. Landscape Industry Certified Interior.
   c. Landscape Industry Certified Horticultural Technician.
5. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near top of root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above root flare for trees up to 4 inch caliper size, and 12 inches above root flare for larger sizes.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of Work. Remove rejected trees or shrubs immediately from Project site.
1. Notify Architect of sources of planting materials 7 days in advance of delivery to site.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:
   1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   3. Accompany each delivery of bulk materials with appropriate certificates.

C. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
   1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

H. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

I. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than 6 hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
   1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for 2 hours. Reject plants with dry roots.
   2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   3. Do not remove container-grown stock from containers before time of planting.
   4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

1.10 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting Work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
   1. Spring Planting: March - June.
   2. Fall Planting: September - November.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.11 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
   1. Failures include the following:
      a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
      b. Structural failures including plantings falling or blowing over.
      c. Faulty performance of tree stabilization.
      d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Periods: From date of planting completion.
      a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
      b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
      c. Annuals: 3 months.
   3. Include the following remedial actions as a minimum:
      a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
      b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
      c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
      d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
   1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between 2 branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots are unacceptable.
   2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label at least 1 plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for plants.

E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number labels to assure symmetry in planting.

F. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of container to maintain a firm ball, but not with

excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
   1. Size: 10 gram tablets.
   2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
   1. Type: Ground or shredded bark.
   2. Size Range: Medium.
   3. Color: Natural.

B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1 inch sieve; soluble-salt content of 2 to 5 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 50 to 60 percent of dry weight.
   2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd.

2.5 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:
   1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2 by 2 inch nominal by length indicated, pointed at one end.
   2. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles.
   3. Guys and Tie Wires: ASTM A641, Class 1, galvanized-steel wire, 2 strand, twisted, 0.106 inch in diameter.
   4. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
   5. Guy Cables: 5 strand, 3/16 inch diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches long, with two 3/8 inch galvanized eyebolts.
   6. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.
   7. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and according to manufacturer's written recommendations.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Arborbrace.

2) Better Bilt Products, Inc.
3) DeepRoot Green Infrastructure, LLC.
4) Foresight Products, LLC.
5) J. R. Partners.
6) Villa Root Barrier.

B. Root-Ball Stabilization Materials:
1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inch nominal by length indicated; stakes pointed at one end.
2. Wood Screws: ASME B18.6.1.
3. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball and that do not encircle trunk; sized according to manufacturer's written recommendations unless otherwise indicated.
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Border Concepts, Inc.
2) Foresight Products, LLC.
3) Tree Staple, Inc.

2.6 MISCELLANEOUS PRODUCTS

A. Root Barrier: Black, molded, modular panels 24 inches high (deep), 85 mils thick, and with vertical root deflecting ribs protruding 3/4 inch out from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. DeepRoot Green Infrastructure, LLC.
b. NDS Inc.

B. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

C. Burlap: Non-synthetic, biodegradable.

D. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTM D448 for Size No. 8.

E. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

F. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5,300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of Work.
1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.

2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until moisture content reaches acceptable levels to attain required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove soil and contamination as directed by Architect and replace with new planting soil.

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

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 – Soil Preparation.

B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade or Blend planting soil in place.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.
1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately 3 times as wide as ball diameter for balled and burlapped, balled and potted, container-grown, and fabric bag-grown stock.
3. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
4. Do not excavate deeper than depth of root ball, measured from root flare to bottom of root ball.
5. If area under plant was initially dug too deep, add soil to raise it to correct level and thoroughly tamp added soil to prevent settling.
6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
7. Maintain supervision of excavations during working hours.

8. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
9. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
1. Hardpan Layer: Drill 6 inch diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from root ball to where top-most root emerges from trunk. After soil removal to expose root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
1. Backfill: Planting soil. For trees, use excavated soil for backfill.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately 1/2 filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately 1/2 filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
   a. Quantity: 3 for each caliper inch of plant.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Balled and Potted and Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
1. Backfill: Planting soil. For trees, use excavated soil for backfill.
2. Carefully remove root ball from container without damaging root ball or plant.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately 1/2 filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets equally distributed around each planting pit when pit is approximately 1/2 filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
   a. Quantity: 3 for each caliper inch of plant.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Fabric Bag-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.
   1. Backfill: Planting soil. For trees, use excavated soil for backfill.
   2. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately 1/2 filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   4. Place planting tablets equally distributed around each planting pit when pit is approximately 1/2 filled. Place tablets beside root ball about 1 inch from root tips; do not place tablets in bottom of hole.
      a. Quantity: 3 for each caliper inch of plant.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil.

F. Bare-Root Stock: Set and support each plant in center of planting pit or trench with root flare 2 inches above adjacent finish grade.
   1. Backfill: Planting soil. For trees, use excavated soil for backfill.
   2. Spread roots without tangling or turning toward surface. Plumb before backfilling, and maintain plumb while working.
   3. Carefully work backfill in layers around roots by hand. Bring roots into close contact with soil.
   4. When planting pit is approximately 1/2 filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   5. Place planting tablets equally distributed around each planting pit when pit is approximately 1/2 filled. Place tablets beside soil-covered roots about 1 inch from root tips; do not place tablets in bottom of hole or touching roots.
      a. Quantity: 3 for each caliper inch of plant.
   6. Continue backfilling process. Water again after placing and tamping final layer of soil.

G. Slopes: When planting on slopes, set plant so root flare on uphill side is flush with surrounding soil on slope; edge of root ball on downhill side will be above surrounding soil. Apply enough soil to cover downhill side of root ball.

3.6 MECHANIZED TREE-SPADE PLANTING

A. Trees may be planted with an approved mechanized tree spade at designated locations. Do not use tree spade to move trees larger than maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than manufacturer's maximum size recommendation for tree spade being used, whichever is smaller.

B. Use same tree spade to excavate planting hole as will be used to extract and transport tree.

C. When extracting tree, center trunk within tree spade and move tree with a solid ball of earth.

D. Cut exposed roots cleanly during transplanting operations.

E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.

F. Where possible, orient tree in same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:
   1. Upright Staking and Tying:
      a. Stake trees of 2- through 5 inch caliper. Stake trees of less than 2 inch caliper only as required to prevent wind tip out. Use a minimum of 2 stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend to dimension indicated on Drawings above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
      b. Stake trees with 2 stakes for trees up to 12 feet high and 2-1/2 inches or less in caliper; 3 stakes for trees less than 14 feet high and up to 4 inches in caliper. Space stakes equally around trees.
   2. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
   3. Support trees with 2 strands of tie wire, connected to brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

3.9 INSTALLATION OF ROOT BARRIER

A. Install root barrier where trees are planted within 48 inches of paving or other hardscape elements, such as walls, curbs, and walkways, unless otherwise indicated on Drawings.

B. Align root barrier with bottom edge angled at 20 degrees away from paving or other hardscape element, and run it linearly along and adjacent to paving or other hardscape elements to be protected from invasive roots.

C. Install root barrier continuously for a distance of 60 inches in each direction from the tree trunk, for a total distance of 10 feet per tree. If trees are spaced closer, use a single continuous piece of root barrier.
   1. Position top of root barrier flush with finish grade.
   2. Overlap root barrier a minimum of 12 inches at joints.
   3. Do not distort or bend root barrier during construction activities.
   4. Do not install root barrier surrounding the root ball of tree.

3.10 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs root system but to a depth not less than 2 nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.11 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 12 inches and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees and Treelike Shrubs in Turf Areas: Apply organic mulch ring of 3 inch average thickness, with 24 inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
   2. Organic Mulch in Planting Areas: Apply 3 inch average thickness of organic mulch extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.12 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.13 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before end of corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
   1. Provide new trees of same size as those being replaced for each tree of [**6 inches**] [**4 inches**] or smaller in caliper size.
   2. Provide 1 new tree(s) of 4 inch caliper size for each tree being replaced that measures more than 4 inches in caliper size.
   3. Species of Replacement Trees: Same species being replaced.

3.14 CLEANING

A. During planting, keep adjacent paving and construction clean and Work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

3.15 PROTECTION

A. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

B. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

C. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.16 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
   1. Maintenance Period: 12 months from date of planting completion.

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
   1. Maintenance Period: 6 months from date of planting completion.

END OF SECTION 329300

SECTION 323913

MANUFACTURED METAL BOLLARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Collapsible bollards.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: For bollards. Use same designations indicated on Drawings.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For metal bollards to include in maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Security Nut Tools: Tools provided or recommended by security nut manufacturer for operating security nuts (not provided by manufacturer).
   1. Type: Bit for drill or power screwdriver.
   2. Quantity: 2
   3. Delivery: Submit tools directly to Owner.

1.5 WARRANTY

A. Materials Warranty: Manufacturer agrees to repair or replace bike parking products that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Materials and Workmanship: 5 years from date of Substantial Completion.
   2. Warranty Period for Coatings: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COLLAPSIBLE BOLLARDS

A. Collapsible Bollards: Premanufactured bollard designed to be reset by hand to upright position. Bollard operates by applying torque to hydrant type nut. Bollard operates on center pivot, allowing it to be lowered and raised.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following:
      a. G. Reale Enterprises Inc.: Maxiforce 1 Collapsible Bollard.
      b. Model # MCSP-SS2-S
      c. Approved substitution.
   2. Extruded Tubing: ASTM A53 cold rolled steel.
   3. Size: 6 inch by 3 inch by 1/4 inch tubing; 32 inches above ground height, with ground anchor base of 18 inches.
   4. Finish: Factory-applied rust inhibiting primer and powder-coat finish.
   5. Color: As selected by Architect from manufacturer's full standard color range.
      a.

2.2 MATERIALS

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
   1. Rolled or Cold-Finished Bars, Rods, and Wire: ASTM B211.
   2. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B221.
   3. Structural Pipe and Tube: ASTM B429.
   4. Sheet and Plate: ASTM B209.
   5. Castings: ASTM B26.

B. Steel and Iron: Free of surface blemishes and complying with the following:
   1. Plates, Shapes, and Bars: ASTM A36.
   2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53, or electric-resistance-welded pipe complying with ASTM A135.
   3. Tubing: Cold-formed steel tubing complying with ASTM A500.
   4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513, or steel tubing fabricated from steel complying with ASTM A1011 and complying with dimensional tolerances in ASTM A500; zinc coated internally and externally.
   5. Sheet: Commercial steel sheet complying with ASTM A1011.
   6. Perforated Metal: From steel sheet not less than [**0.075 inch**] [**0.090 inch**] [**0.120 inch**] nominal thickness; manufacturer's standard perforation pattern.
   7. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
   8. Malleable-Iron Castings: ASTM A47, grade as recommended by fabricator for type of use intended.
   9. Gray-Iron Castings: ASTM A48, Class 200.

C. Stainless Steel: Free of surface blemishes and complying with the following:
   1. Sheet, Strip, Plate, and Flat Bars: ASTM A 666.
   2. Pipe: Schedule 40 steel pipe complying with ASTM A 312.
   3. Tubing: ASTM A 554.

D. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.

E. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
   1. Polyethylene: Fabricated from virgin plastic HDPE resin.
   2. Recycled Content of Polyethylene: Postconsumer recycled content plus 1/2 of preconsumer recycled content not less than <**Insert number**> percent.

F. Anchors, Fasteners, Fittings, and Hardware: Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials Stainless steel; commercial quality, tamperproof, vandal and theft resistant, concealed, recessed, and capped or plugged.
   1. Angle Anchors: For inconspicuously bolting legs of site furnishings to on-grade substrate; 1 per leg [**extent as indicated**.
   2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; [**2 per unit**] [**extent as indicated on Drawings**].

G. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107; recommended in writing by manufacturer, for exterior applications.

H. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure

without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

I. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
   1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil thick.
   2. Hot-Dip Galvanizing: Per ASTM A123, ASTM A153, or ASTM A924.

2.3 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure-treat wood according to AWPA U1 and the following:
   1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
   2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.4 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

F. Factory Assembly: Assemble components in the factory to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.5 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 ALUMINUM FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.7 STEEL AND GALVANIZED-STEEL FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.8 IRON FINISHES

A. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.9 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
1. Run directional finishes with long dimension of each piece.
2. Directional Satin Finish: No 4.
3. Dull Satin Finish: No. 6.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of Work.

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

3.2 INSTALLATION, GENERAL

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

3.3 CLEANING AND ADJUSTING

A. Clean finished surfaces, and remove wrappings and debris from Project site.

B. Adjust moving parts for smooth operation.

3.4 PROTECTION

A. Protect site furnishings with protective covers until date of Substantial Completion.

END OF SECTION 323913

SECTION 331100

WATER DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes:

1. Waterlines
2. Water meters and vaults
3. Valves
4. Fire hydrants
5. Various appurtenances

B. Related Sections:

1. 310000 – Earthwork
2. 321216 – Asphalt Concrete Paving
3. 321613 – Cement Concrete Paving

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Pipe and fittings shall conform to the City of Everett Standards/Specifications and the WSDOT Standard Specifications Section 9-30.1(1) for water mains. Refer to the City of Everett Design and Construction Standards and Specifications for Development Section 5-6 Pipe and Fittings for Water Mains.

B. Pipe and fittings shall conform to the City of Everett Standards/Specifications and the WSDOT Standard Specifications Sections 9-30.6(3)B and 9-30.6(4) for service connections 2” and smaller. A number 10 copper trace wire is required for polyethylene pipe. All service lines 3 inches and larger shall be cement lined ductile iron pipe (Special Class 52) from the main to the meter meeting the requirements of 2.1A.

2.2 VALVES

A. Valves shall meet the requirements of City of Everett Design and Construction Standards and Specifications for Development Section 5-10 Valves for Water Mains.

B. Gate valves shall conform to Section 5-10.5 of the City of Everett Design and Construction Standards and Specifications for Development. Install valve boxes on all valves.

2.3 VALVE BOXES AND EXTENTIONS

A. Valve boxes in paved areas shall be cast iron, two-piece units, as manufactured by East Jordan 8555 16" top, 24" bottom and East Jordan 6800 Heavy Duty lid with "WATER" on lid; or City of Everett approved equivalent.

B. Valve boxes in grass, non-paved or non-traffic areas use of plastic valve boxes with cast iron lid as manufactured by Handley Industries or City of Everett approved equivalent.

2.4 FIRE HYDRANTS

A. Hydrants and all materials shall conform to AWWA Standards and shall be of standard manufacture (Mueller Super Centurion #250, Waterous Pacer #WB67, or City of Everett approved equal. Refer to City of Everett Standard Drawing Nos. 507 and 508.

2.5 POST-INDICATOR VALVE

A. Post Indicator Valve (PIV) shall be UL listed and FM approved. Indicator post shall be round, full length, and adjustable cast iron body mounted over a non-rising stem gate valve. Height of control nut for PIV shall be 36 to 42 inches above finished grade. Provide a 36-inch minimum clearance radius to any obstruction.

2.6 FIRE DEPARTMENT CONNECTION

A. Fire Department Connection (FDC) shall be freestanding pipe mount cast brass double clapper 2-way Siamese connection threaded to match local fire department hardware, dust caps and chains of same material and finish. Connection shall be according to NFPA 1963 and UL 405.

B. FDC shall be equipped with an escutcheon indicating “Fire Department Connection” in accordance with NFPA 14. Lettering shall be a minimum of 1 inch tall.

2.7 DOUBLE-CHECK VALVE ASSEMBLY

A. Double Check Valve Assembly shall conform to City of Everett Standard Specifications and Drawings. Refer to City of Everett Standard Drawing 520.

2.8 CONCRETE

A. Unreinforced concrete shall be commercial class conforming to Section 6-02.3(2)B of the WSDOT Standard Specifications.

2.9 DETECTABLE MARKING TAPE

A. Detectable marking tape shall conform to 9-15.18 of the WSDOT Standard Specifications.

PART 3 - EXECUTION

3.1 TRENCHES

A. Excavate and backfill trenches, and bed the piping in conformance with City of Everett Standard Drawing No. 620 and Section 5-7.4 of the City of Everett Specifications.

3.2 PIPES AND VALVES

A. Install pipes and valves in conformance with Section 7-09.3 and 7-12.3 of the WSDOT Standard Specifications.

3.3 SERVICE CONNECTIONS

A. Install service connections in conformance with Section 7-15.3 of the WSDOT Standard Specifications.

3.4 FIRE HYDRANTS

A. Install fire hydrants in conformance with Section 7-14.3 of the WSDOT Standard Specifications and City of Everett Standard Drawing Nos. 507 and 508.

3.5 POST INDICATOR VALVE

A. Install post indicator valve in conformance with manufacturer's recommendations.

3.6 FIRE DEPARTMENT CONNECTION

A. Install fire department connector in conformance with manufacturer's recommendations.

3.7 DETECTABLE MARKING TAPE

A. Install detectable marking tape on all new waterlines in accordance with Section 7-09.3(20) of the WSDOT Standard Specifications.

3.8 TESTING AND CLEANING

A. Water system shall pressure-tested in conformance with Section 7-09.3(23) of the WSDOT Standard Specifications. Refer to the City of Everett Design and Construction Standards and Specifications for Development Section 5-14 Hydrostatic Pressure Test.

B. Clean and flush water systems in conformance with the City of Everett Design and Constructions Standards and Specifications for Development Sections 5-15 through 5-15.10.

C. Coordinate all Testing and Cleaning with the City of Everett Public Works Inspector. Perform all testing and cleaning in the presence of a City of Everett Public Works Engineer/Inspector.

END OF SECTION 331100

SECTION 333000

SANITARY SEWERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work includes constructing sanitary sewer mains, side sewers, and manholes.

B. Related sections:

1. 310000 – Earthwork
2. 321216 – Asphalt Concrete Paving
3. 321613 – Cement Concrete Paving

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

2.1 PIPE

A. Sewer pipe shall conform to Section 7-17.2 of the WSDOT Standard Specifications. Legibly and permanently, mark all pipes and fittings with type and class.

B. Sanitary sewer service laterals shall be solid wall PVC pipe. PVC pipe, joints, and fittings shall conform to Section 9-05.12(1) of the WSDOT Standard Specifications.

2.2 MANHOLES

A. Manholes shall be precast concrete structures conforming to Section 7-05.2 of the WSDOT Standard Specifications and the City of Everett Standard Drawings 605, 606, and 607.

B. Manhole frames and covers shall conform to the City of Everett Standard Drawing 611.

2.3 CLEANOUTS

A. Cleanout shall conform to the City of Everett Standard Drawing 604 for paved and unpaved areas.

B. Cleanouts shall be of the same material as the pipe and shall conform to Section 7-19.2 of the WSDOT Standard Specifications.

PART 3 - EXECUTION

3.1 PIPE

A. Install pipe in conformance with Sections 7-17.3 and 7-18.3 of the WSDOT Standard Specifications and the City of Everett Specification Section 6-7. Refer to Section 310000 – Earthwork for Gravel Backfill for Pipe Zone Bedding requirements.

B. Side sewer construction shall conform to the City of Everett Design and Construction Standards and Specifications for Development Standard Drawings 601, 602, 603, and 604.

3.2 MANHOLES

A. Installation of manholes shall conform to Section 7-05.3 of the WSDOT Standard Specifications and the City of Everett Design and Construction Standards and Specifications for Development Section 6-6.3.

3.3 CLEANOUTS

A. Install cleanouts in conformance with Section 7-19.3 of the WSDOT Standard Specifications.

3.4 CLEANING AND TESTING

A. Clean and test all sewers and appurtenances, after backfilling, by the low-pressure air method specified in Section 7-17.3(2) of the WSDOT Standard Specifications. Perform all testing in the presence of the City of Everett Engineer.

B. All new sewer mains and mains within easements maintained by the City of Everett require television inspections by the City Sewer Division. Contractor shall coordinate all inspections with the City of Everett Engineer.

END OF SECTION 333000

SECTION 334000

STORM DRAINAGE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Work shall consist of furnishing and installing detention, water quality and storm drainage systems including piping, manholes, catch basins, area drains, cleanouts and underdrains in accordance with the plans and these specifications at the locations and in conformity with lines and grades established in the Contract Documents.

B. Related Sections:

1. 310000 – Earthwork

2. 334616 – Subdrainage Systems

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

2.1 PIPE

A. Drainage pipe shall conform to Section 7-04.2 of the WSDOT Standard Specifications.

2.2 CATCH BASINS AND MANHOLES

A. Catch basins and manholes shall be precast concrete structures conforming to Section 9-05.50 of the WSDOT Standard Specifications and the City of Everett Standard Drawings and Specifications.

2.3 CLEANOUTS

A. Cleanouts shall be of the same material as the pipe and shall conform to Section 7-19.2 of the WSDOT Standard Specifications.

PART 3 - EXECUTION

3.1 PIPE

A. Install pipe in conformance with Section 7-04.3 of the WSDOT Standard Specifications as modified by the City of Everett. Refer to Section 310000 – Earthwork for Gravel Backfill for Pipe Zone Bedding requirements.

3.2 CATCH BASINS AND MANHOLES

A. Install catch basins and manholes in conformance with Section 7-05.3 of the WSDOT Standard Specifications.

3.3 CLEANOUTS

A. Install cleanouts in conformance with Section 7-19.3 of the WSDOT Standard Specifications.

3.4 CLEANING AND TESTING

A. All storm drains and appurtenances shall be cleaned and tested in accordance with the low pressure air method specified in Section 7-04.3(1) of the WSDOT standard specifications.

END OF SECTION 334000

SECTION 334616

SUBDRAIN SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work includes constructing underdrain perimeter foundation drains, underslab drains, wall drains, and shoring wall drain systems.

1.2 STANDARD SPECIFICATIONS

A. All work to be performed and materials to be used shall be in accordance with the 2020 Standard Specifications and Standard Plans for Road, Bridge and Municipal Construction, as published by the Washington State Department of Transportation (WSDOT), as modified by the City of Everett Design and Construction Standards and Specifications for Development; latest edition.

B. The Contractor shall have one copy of the Standard Specifications and Standard Plans at the job site.

C. The Standard Specifications apply only to performance and materials and how they are to be incorporated into the work. The legal/contractual relationship sections, and the measurement and payment sections do not apply to this document.

PART 2 - PRODUCTS

2.1 PIPE

A. Perforated PVC underdrain pipe shall conform to Section 9-05.2(6) of the WSDOT Standard Specifications. Perforated pipe shall have either round or slotted perforations. Perforations shall be shop drilled to the size and spacing noted on the Drawings.

B. Wall drainage pipe may be perforated corrugated polyethylene pipe, Type SP, Class 2, and conform to WSDOT Standard Specifications Section 9-05.2(7) or as specified above 2.1.A.

2.2 SHORING WALL DRAINAGE

A. Composite drainage board shall be Miradrain 6000, unless otherwise noted on the drawing.

2.3 FILTER FABRIC

A. Filter fabric shall be Mirafi 140N or an approved equal.

2.4 GRAVEL BACKFILL FOR DRAINS

A. Refer to Section 310000 - Earthwork.

2.5 CLEANOUTS

A. Cleanouts shall be of the same material as the pipe, without perforations and shall conform to Section 7-19.2 of the WSDOT Standard Specifications.

PART 3 - EXECUTION

3.1 PIPE

A. Install pipe in conformance with Section 7-01.3 of the WSDOT Standard Specifications. Except that pipe trench shall be excavated as shown on the City of Everett Drawings.

3.2 CLEANOUTS

A. Install cleanouts in conformance with Section 7-19.3 of the WSDOT Standard Specifications.

END OF SECTION 334616