Lee's Summit Robotics, GiC & Phys Education

Project Manual
Volume 2 of 3

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multistudio

SECTION 220010 - GENERAL PLUMBING REQUIREMENTS

PART 1 - GENERAL REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. This Division requires the furnishing and installing of complete functioning systems, and each element thereof, as specified or indicated on the Drawings and Specifications or reasonably inferred; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include materials, labor, supervision, supplies, equipment, transportation, and utilities.

B. Division 22 of the Specifications and Drawings numbered with prefixes P, MP and EP generally describe these systems, but the scope of the Plumbing work includes all such work indicated in the Contract Documents: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.

C. The Drawings have been prepared diagrammatically intended to convey the scope of work, indicating the intended general arrangement of the equipment, fixtures, piping, etc. without showing all the exact details as to elevations, offsets, control lines, and other installation requirements. The Contractor shall use the Drawings as a guide when laying out the work and shall verify that materials and equipment will fit into the designated spaces, and which, when installed per manufacturers requirements, will ensure a complete, coordinated, satisfactory and properly operating system.

1.2 QUALITY ASSURANCE

A. All work under this division shall be executed in a thorough professional manner by competent and experienced workmen licensed to perform the Work specified.

B. All work shall be installed in strict conformance with manufacturer's requirements and recommendations. Equipment and materials shall be installed in a neat and professional manner and shall be aligned, leveled, and adjusted for satisfactory operation.

C. Material and equipment shall be new, shall be of the best quality and design, shall be current model of the manufacturer, shall be free from defects and imperfections and shall have markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Material and equipment of the same type shall be made by the same manufacturer whenever practicable.

D. Unless specified otherwise, manufactured items shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this project.

1.3 CODES, REFERENCES AND STANDARDS

A. Execute Work in accordance with the National Fire Protection Association and all Local, State, and National codes, ordinances and regulations in force governing the particular class of Work involved. Obtain timely inspections by the constituted authorities, and upon final completion of

the Work obtain and deliver to the Owner executed final certificates of acceptance from the Authority Having Jurisdiction.

B. Any conflict between these Specifications and accompanying Drawings and the applicable Local, State and Federal codes, ordinances and regulations shall be reported to the Architect in sufficient time, prior to the opening of Bids, to prepare the Supplementary Drawings and Specification Addenda required to resolve the conflict.

C. The governing codes are minimum requirements. Where these Drawings and Specifications exceed the code requirements, these Drawings and Specification shall prevail.

D. All material, manufacturing methods, handling, dimensions, method or installation and test procedure shall conform to but not be limited to the following industry standards and codes:

IBC	International Building Code – 2018
IMC	International Mechanical Code – 2018
IPC	International Plumbing Code – 2018
IFGC	International Fuel Gas Code – 2018
IECC	City of Lee's Summit Energy Conservation Code
ADA	American Disabilities Act
ANSI	American National Standards Institute
ASSE	American Society of Sanitary Engineering
ASTM	American Society of Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
CISPI	Cast Iron Soil Pipe Institute
MSS	Manufacturer's Standardization Society of the Valve and Fitting Industry
NBFU	National Board of Fire Underwriters
NEC	National Electrical Code
NFPA	National Fire Protection Association
NEMA	National Electrical Manufactures' Association
OSHA	Occupational Safety and Health Act
PDI	Plumbing and Drainage Institute
UL	Underwriter's Laboratories

E. Contractor shall comply with rules and regulations of public utilities and municipal departments affected by connections of services.

F. All Plumbing work shall be performed in compliance with applicable safety regulations, including OSHA regulations. Safety lights, guards, shoring and warning signs required for the performance of the Plumbing work shall be provided by the Contractor.

1.4 DEFINITIONS

A. General:

1. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation and similar operations."
2. Install: The term "install" is used to describe operations at the project site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
3. Provide: The term "provide" means "to furnish and install, complete and ready for the intended use."

4. Furnished by Owner or Furnished by Others: The item will be furnished by the Owner or Others. It is to be installed and connected under the requirements of this Division, complete and ready for operation, including items incidental to the Work, including services necessary for proper installation and operation. The installation shall be included under the guarantee required by this Division.

5. Engineer: Where referenced in this Division, "Engineer" is the Engineer of Record and the Design Professional for the Work under this Division, and is a Consultant to, and an authorized representative of, the Architect, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the "Architect".
6. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.
7. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other listed Manufacturers and models that meet the specified criteria.
8. Substitution: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor. Substitutions include Value Engineering proposals.

    a. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
    b. Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.

9. Value Engineering: A systematic method to improve the "value" of goods and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. The goal of VE is to achieve the desired function at the lowest overall cost consistent with required performance.

B. The terms "approved equal", "equivalent", or "equal" are used synonymously and shall mean "accepted by or acceptable to the Engineer as equivalent to the item or manufacturer specified". The term "approved" shall mean labeled, listed, or both, by an NRTL, and acceptable to the AHJ over this project.

C. The following definitions apply to excavation operations:

1. Additional Excavation: Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
2. Bedding: as used in this Section refers to the compacted sand or pea gravel installed in the bottom of a pipe trench to immediately support a pipe and cover a pipe.
3. Subbase: as used in this Section refers to the compacted soil layer used in pavement systems between the subgrade and the pavement base course material.
4. Subgrade: as used in this Section refers to the compacted soil immediately below the slab or pavement system.
5. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction from the Architect.

6. Drainage Fill: as used in this Section refers to gravel installed to assist in the removal of underslab groundwater.
7. Building Fill: as used in this section refers to borrowed fill material of rock 1" and larger used to fill foundation excavations.

1.5 COORDINATION

A. The Contractor shall visit the site and ascertain the conditions to be encountered while installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make due provision for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, incorrect or faulty installation of Work under this Division or for additional compensation for Work covered by this Division.

B. The Contractor shall refer to Drawings of the other disciplines and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. The Contractor shall make offsets required to clear equipment, beams and other structural members; and to facilitate concealing piping and ductwork in the manner anticipated in the design.

C. The contractor shall provide materials with trim which will fit properly the types of ceiling, wall, or floor finishes actually installed.

D. The Contractor shall maintain a foreman on the jobsite at all times to coordinate his work with other contractors and subcontractors so that various components of the Plumbing systems will be installed at the proper time, will fit the available space, and will allow proper service access to the equipment. Carry on the Work in such a manner that the Work of the other contractors and trades will not be handicapped, hindered, or delayed at any time.

E. Work of this Division shall progress according to the "Construction Schedule" as established by the Prime Contractor and his subcontractors and as approved by the Architect. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule so as to ensure successful achievement of schedule dates.

1.6 MEASUREMENTS AND LAYOUTS

A. The drawings are schematic in nature, but show the various components of the systems approximately to scale and attempt to indicate how they are to be integrated with other parts of the building. Figured dimensions shall be taken in preference to scale dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing the Contract Documents. The Contractor will be held responsible for errors which could have been avoided by proper checking and inspection.

1.7 SUBMITTALS

A. Refer to Division 1 and General Conditions for submittal requirements in addition to requirements specified herein.

B. Submittals and shop drawings shall not contain the firm name, logo, seal, or signature of the Engineer. They shall not be copies of the work product of the Engineer. If the Contractor desires

to use elements of such product, the license agreement for transfer of information obtained from the Engineer must be used.

C. Assemble and submit for review manufacturer product literature for material and equipment to be furnished and/or installed under this Division. Literature shall include shop drawings, manufacturer product data, performance sheets, samples and other submittals required by this Division as noted in Table 1 at the end of this Section. Provide the number of submittals required by Division 1; if hard-copy sets are provided, submit a minimum of seven (7) sets. General product catalog data not specifically noted to be part of the specified product will be rejected and returned without review.

D. Separate submittals according to individual specification sections. Only resubmit those sections requested for resubmittal.

E. Provide submittals in sufficient detail so as to demonstrate compliance with these Contract Documents and the design concept. Highlight, mark, list or indicate the materials, performance criteria and accessories that are being proposed. Illegible submittals will be rejected and returned without review.

F. Refer to individual Sections for additional submittal requirements.

G. Transmit submittals as early as required to support the project schedule. Allow two weeks for Engineer review time, plus to/from mailing time via the Architect, plus a duplication of this time for resubmittals, if required. Transmit submittals as soon as possible after Notice to Proceed and before Plumbing construction starts.

H. Before transmitting submittals and material lists, verify that the equipment submitted is mutually compatible with and suitable for the intended use. Verify that the equipment will fit the available space and maintain manufacturer recommended service clearances. If the size of equipment furnished makes necessary any change in location, or configuration, submit a shop drawing showing the proposed layout.

I. Submittals shall contain the following information:

1. The project name.
2. The applicable specification section and paragraph.
3. Equipment identification acronym as used on the drawings.
4. The submittal date.
5. The Contractor's stamp, which shall certify that the stamped drawings have been checked by the Contractor, comply with the Drawings and Specifications, and have been coordinated with other trades.
6. Submittals not so identified will be returned to the Contractor without action.

J. Refer to Division 1 for acceptance of electronic submittals for this project. For electronic submittals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 1. Contractor shall notify the Architect and Engineer that the submittals have been posted. If electronic submittal procedures are not defined in Division 1, Contractor shall include the website, user name and password information needed to access the submittals. For submittals sent by e-mail, Contractor shall copy the Architect and Engineer's designated representatives. Contractor shall allow for the Engineer review time as specified above in the construction schedule. Contractor shall submit only the documents required to purchase the materials and/or equipment in the submittal.

K. The checking and subsequent acceptance by the Engineer and/or Architect of submittals shall not relieve responsibility from the Contractor for (1) deviations from the Drawings and

Specifications; (2) errors in dimensions, details, sizes of equipment, or quantities; (3) omissions of components or fittings; and (4) not coordinating items with actual building conditions and adjacent work. Contractor shall request and secure written acceptance from the Engineer and Architect prior to implementing any deviation.

L. Provide welders' qualification certificates.

1.8 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files from the Engineer. Contact the Architect for Architect's written authorization. Contractor shall request and complete the Electronic File Release Agreement form from the Engineer. Contractor shall indicate the desired shipping method and drawing format on the form. Architect's written authorization and Engineer's release agreement form must be received before electronic drawing files will be sent.

1.9 SUBSTITUTIONS

A. Refer to Division 01 and General Conditions for substitutions in addition to requirements specified herein.

B. Materials, products, equipment, and systems described in the Bidding Documents establish a standard of required function, dimension, appearance and quality to be met by the proposed substitution.

C. The base bid shall include only the products from manufacturers specifically named in the drawings and specifications.

D. Request for Substitution:

1. Complete and send the Substitution Request Form attached at the end of this section for each material, product, equipment, or system that is proposed to be substituted.
2. The burden of proof of the merit of the proposed substitution is upon the proposer.
3. Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner the following:

    a. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
    b. Proposed substitution is consistent with the Contract Documents and will produce indicated results, including functional clearances, maintenance service, and sourcing of replacement parts.
    c. Proposed substitution has received necessary approvals of authorities having jurisdiction.
    d. Same warranty will be furnished for proposed substitution as for specified Work.
    e. If accepted substitution fails to perform as required, Contractor shall replace substitute material or system with that originally specified and bear costs incurred thereby.
    f. Coordination, installation and changes in the Work as necessary for accepted substitution will be complete in all respects.

E. Substitution Consideration:

1. No substitutions will be considered unless the Substitution Request Form is completed and attached with the appropriate substitution documentation.

2. No substitution will be considered prior to receipt of Bids unless written request for approval to bid has been received by the Engineer at least ten (10) calendar days prior to the date for receipt of Bids.
3. If the proposed substitution is approved prior to receipt of Bids, such approval will be stated in an Addendum. Bidders shall not rely upon approvals made in any other manner. Verbal approval will not be given.
4. No substitutions will be considered after the Contract is awarded unless specifically provided in the Contract Documents.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 1 and General Conditions for Operation and Maintenance Manuals in addition to requirements specified herein.

B. Submit manuals prior to requesting the final punch list and before all requests for Substantial Completion.

C. Instruct the Owner's permanent personnel in the proper operation of, startup and shutdown procedures and maintenance of the equipment and components of the systems installed under this Division.

D. Prior to Substantial Completion of the project, furnish to the Architect, for Engineer's review, and for the Owner's use, four (4) copies of Operation and Maintenance Manuals in labeled, hard-back three-ring binders, with cover, binding label, tabbed dividers and plastic insert folders for Record Drawings. Include local contacts, complete with address and telephone number, for equipment, apparatus, and system components furnished and installed under this Division of the specifications.

E. Each manual shall contain data listed in Table 5.

F. Refer to Division 1 for acceptance of electronic manuals for this project. For electronic manuals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 1. Contractor shall notify the Architect and Engineer that the manuals have been posted. If electronic manual procedures are not defined in Division 1, Contractor shall include the website, user name and password information needed to access the manuals. For manuals sent by e-mail, Contractor shall copy the Architect and Engineer's designated representatives.

1.11 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections in Division 22 of this specification. Refer to Table 2 at the end of this section for a list of specification sections in Division 22 that contain spare parts requirements.

B. Owner or Owner's representative shall initial and date each section line in Table 2 when the specified spare parts for that section are received and shall sign at the bottom when all spare parts have been received.

1.12 RECORD DRAWINGS

A. Refer to Division 01 and General Conditions for Record Drawings in addition to requirements specified herein.

B. A set of work prints of the Contract Documents shall be kept on the jobsite during construction for the purpose of noting changes. During the course of construction, the Contractor shall indicate on these Documents changes made from the original Contract Documents. Particular attention shall be paid to those items which need to be located for servicing. Underground utilities shall be located by dimension, from column lines.

C. At the completion of the project, the Contractor shall obtain, at their expense, reproducible copies of the final drawings and incorporate changes noted on the jobsite work prints onto these drawings. These changes shall be done by a skilled drafter. Each sheet shall be marked "Record Drawing", along with the date. These drawings shall be delivered to the Architect/Engineer.

1.13 TRAINING

A. Provide training as indicated in each specific section. Schedule training with the Owner at least 7 days in advance. Video tape the training sessions in format as agreed to with the Owner. Provide three copies of each session to the Owner and obtain written receipt from the Owner.

1.14 PAINTING

A. Exposed ferrous surfaces, including pipe, pipe hangers, equipment stands and supports and exposed insulated piping shall be painted by the Plumbing Contractor using materials and methods as specified under Division 9 of the Specifications; colors shall be as selected by the Architect.

B. Factory finishes, shop priming and special finishes are specified in the individual equipment specification sections.

C. Where factory finishes are provided and no additional field painting is specified, marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish.

1.15 DELIVERY, STORAGE AND HANDLING

A. Refer to Division 1 and General Conditions for Delivery, Storage and Handling in addition to requirements specified herein.

B. Equipment and material shall be delivered to the job site in their original containers with labels intact, fully identified with manufacturer's name, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.

C. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and at all times, take every precaution to properly protect equipment and material from damage, to include the erection of temporary shelters to adequately protect equipment and material stored at the Site. Equipment and/or material which become rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to the Architect.

D. The Contractor shall be responsible for the safe storage of his own tools, material and equipment.

1.16 GUARANTEES AND WARRANTIES

A. Refer to Division 1 and General Conditions for Guarantees and Warranties in addition to requirements specified herein.

B. Each system and element thereof shall be warranted against defects due to faulty workmanship, design or material for a period of 12 months from date of Substantial Completion, unless specific items are noted to carry a longer warranty in the Construction Documents or manufacturer's standard warranty. The Contractor shall remedy defects occurring within a period of one year from the date of Substantial Completion or as stated in the General Conditions.

C. The following additional items shall be guaranteed:

1. Piping shall be free from obstructions, holes or breaks of any nature.
2. Insulation shall be effective.
3. Proper circulation of fluid in each piping system.

D. The above guarantees shall include both labor and material; and repairs or replacements shall be made without additional cost to the Owner.

E. The remedial work shall be performed promptly, upon written notice from the Architect or Owner.

F. At the time of Substantial Completion, deliver to the Owner warranties with terms extending beyond the one year guarantee period, each warranty instrument being addressed to the Owner and stating the commencement date and term. Refer to Table 3 at the end of this section for a list of specification sections in Division 22 that contain special warranties.

1.17 TEMPORARY FACILITIES

A. Refer to Division 1 and General Conditions for Temporary Facilities requirements in addition to requirements specified herein.

B. Temporary Utilities: The types of services required include, but are not limited to, water, sewerage, surface drainage and gas. When connecting to existing franchised utilities for required services, comply with service companies' recommendations on materials and methods, or engage service companies to install services. Locate and relocate services (as necessary) to minimize interference with construction operations.

1. Water: Premises are supplied with water services which may be used in this work: Contractor shall make his own arrangements for water services.
2. Sewer Sediment: Maintain sewers and temporary connecting sewers in a clean, nonclogged condition during construction period.

C. Construction Facilities: Provide facilities reasonably required to perform construction operations properly and adequately.

1. Enclosures: When temporary enclosures are required to ensure adequate workmanship, weather protection and ambient conditions required for the work, provide fire-retardant treated lumber and plywood; provide tarpaulins with UL label and flame spread of 15 or less; provide translucent type (nylon reinforced polyethylene) where daylighting of enclosed space would be beneficial for workmanship, and reduce use of temporary lighting.

1.18 PROJECT CONDITIONS

A. Conditions Affecting Work In Existing Buildings:

1. The Drawings describe the general nature of remodeling to the existing building. However, the Contractor shall visit the Site prior to submitting His bid to determine the nature and extent of work involved.
2. Work in the existing building shall be scheduled with the Owner.
3. Certain demolition work must be performed prior to the remodeling. The Plumbing Contractor shall perform the demolition which involves Plumbing and Plumbing systems, fixtures, equipment, piping, equipment supports or foundations and materials.
4. Plumbing Contractor shall remove articles which are not required for the new Work. Unless otherwise indicated, each item removed by the Plumbing Contractor during this demolition shall become his property and shall be removed by the Plumbing Contractor from the premises and dispose of them in accordance with applicable federal, state and local regulations.
5. Plumbing Contractor shall relocate and reconnect Plumbing facilities that must be relocated in order to accomplish the remodeling shown in the Drawings or indicated in the Specifications. Where Plumbing equipment or materials are removed, the Plumbing Contractor shall cap unused piping beyond the floor line or wall line to facilitate restoration of finish.
6. General Contractor shall install finish material.
7. Obtain permission from the Architect for channeling of floors or walls not specifically noted on the Drawings.
8. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
9. Locate, identify, and protect Plumbing services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

B. Conditions Affecting Excavations: The following project conditions apply:

1. Maintain and protect existing building services which transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.

C. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.

D. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

PART 2 - PRODUCTS AND MATERIALS

2.1 SOIL MATERIALS

A. Provide clean sand, pea gravel or flowable fill material (per the geotechnical engineer's or structural engineer's recommendations).

B. Subbase Material: Where applicable, provide natural soils with 10% by volume of rocks less than 2" diameter or artificially crushed aggregate. Corrosive fill materials shall not be utilized. When CL clay, rock, or gravel is used, it shall not be larger than 2 inches in any dimension and be free of debris, waste, frozen materials, vegetable and other deleterious matter.

C. Filter Fabric: Flat needle punched PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4,480 to 13,440 L/min. per sq. m) when tested according to ASTM D 4491.

PART 3 - EXECUTION

3.1 PERMITS

A. Secure and pay for permits required in connection with the installation of the Plumbing Work. Arrange with the various utility companies for the installation and connection of required utilities for this facility and pay charges associated therewith including connection charges and inspection fees, except where these services or fees are designated to be provided by others.

3.2 EXISTING UTILITIES

A. Schedule and coordinate with the Utility Company, Owner and with the Engineer connection to, or relocation of, or discontinuation of normal utility services from existing utility lines. Premium time required for any such work shall be included in the bid.

B. Existing utilities damaged due to the operations of utility work for this project shall be repaired to the satisfaction of the Owner or Utility Company without additional cost.

C. Utilities shall not be left disconnected at the end of a work day or over a weekend unless authorized by representatives of the Owner or Engineer.

D. Repairs and restoration of utilities shall be made before workmen leave the project at the end of the workday in which the interruption takes place.

E. Contractor shall include in his bid the cost of furnishing temporary facilities to provide services during interruption of normal utility service.

3.3 SELECTIVE DEMOLITION

A. Refer to Division 01, Division 02 and General Conditions for Selective Demolition requirements in addition to the requirements specified herein.

B. General: Demolish, remove, demount, and disconnect abandoned Plumbing materials and equipment indicated to be removed and not indicated to be salvaged or saved.

C. Materials and Equipment To Be Salvaged: Remove, demount, and disconnect existing Plumbing materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.

D. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

E. Plumbing Materials and Equipment: Demolish, remove, demount, and disconnect the following items:

1. Inactive and obsolete piping, fittings and specialties, equipment, controls, fixtures and insulation.

a. Piping embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove exposed materials and materials above accessible ceilings. Drain and cap piping and ducts allowed to remain.
b. Perform cutting and patching required for demolition in accordance with Division 1, General Conditions and "Cutting and Patching" portion of this Section in Division 22.

3.4 EXCAVATION AND BACKFILLING

A. Refer to Division 01, Division 02, and Division 31, Geotechnical Soils Report and General Conditions for Excavation and Backfilling in addition to the requirements specified herein.

B. Perform excavation of every description, of whatever substance encountered and to the depth required in connection with the installation of the work under this Division. Excavation shall be in conformance with applicable Division and section of the General Specifications.

C. Roads, alleys, streets and sidewalks damaged during this work shall be restored to the satisfaction of Authorities Having Jurisdiction.

D. Trenches close to walks or columns shall not be excavated without prior consultation with the Architect.

E. Erect barricades around excavations. Provide an adequate number of amber lights on or near the work and keep them burning from dusk to dawn. The Contractor shall be held responsible for any damage that any parties may sustain due to neglecting the necessary precautions when performing the work.

F. Slope sides of excavations to comply with local, state and federal codes and ordinances. Shore and brace as required for stability of excavation.

G. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local, state and federal codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.

H. Install sediment and erosion control measures in accordance with local codes and ordinances.

I. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and trenches.

1. Do not allow water to accumulate in excavations and trenches. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
2. Establish and maintain temporary drainage ditches and other diversions outside excavation and trench limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches. In no case shall sewers be used as drains for such water.

J. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

K. Trenching: Excavate trenches for Plumbing installations as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of pipe and equipment.
2. Excavate trenches to depth indicated or required for piping to establish indicated slope and invert elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.
3. Limit the length of open trench to that in which pipe can be installed, tested, and the trench backfilled within the same day.
4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of pipe. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and pipe.
5. Excavate trenches for piping and equipment with bottoms of trench to accurate elevations for support of pipe and equipment on undisturbed soil.

L. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35°F.

M. Bedding:

1. Fill bottom of pipe trench and fill unevenness with compacted bedding material to ensure continuous bearing of the pipe barrel on the bearing surface. Additional bedding installation requirements are in the following piping specifications. Compact bedding as described below:
2. Fill bottom of equipment trench and fill unevenness with compacted sand backfill to ensure continuous bearing of the equipment on the bearing surface. Compact bedding as described below.

N. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.

1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
2. Under building slabs, use drainage fill materials.
3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.

4. For piping less than 30 inches below surface of roadways, provide 4-inch-thick concrete base slab support after installation and testing of piping and prior to backfilling and placement of roadway subbase. Coordinate with AHJ for colored concrete requirements.
5. Other areas, use excavated or borrowed materials.

O. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval, and locations of underground utilities have been recorded.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids.
4. Removal of trash and debris.

P. Placement and Compaction: Place subgrade backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

Q. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

R. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of piping and equipment by carrying material uniformly around them to approximately same elevation in each lift.

S. Compaction: Place bedding backfill materials in maximum layers of not more than 6 inches loose depth for material compacted by hand-operated tampers. Place subbase backfill materials in maximum layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers. Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

1. Use of pneumatic backhoe as compaction method is not allowed as an acceptable process for compaction of excavations or trenches.
2. For vertical and/or diagonal pipe installations greater than ½" rise/lf, thoroughly support pipes from permanent concrete structures or undisturbed earth at no less than 10-foot intervals, while placing backfill materials, so that pipes are not deflected, crushed, broken, or otherwise damaged by the backfill placement or settlement.
3. Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
4. Place backfill and/or drainage fill materials evenly adjacent to structures, piping, and equipment to required elevations. Coordinate with Architect and/or Civil Engineer backfill requirements prior to installation. Prevent displacement of pipes and equipment by carrying material uniformly around them to approximately same elevation in each layer or lift.
5. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 or ASTM D 698 and not less than the following percentages of relative density, determined in accordance with ASTM D 4253, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

a. Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
b. Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
c. Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

T. Subsidence: Where subsidence occurs at Plumbing installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

U. Additional Excavation: Where additional excavation may be required due to unsuitable bearing materials encountered, notify the architect immediately for resolution.

3.5 CUTTING AND PATCHING

A. The Contractor shall do necessary cutting of walls, floors, ceilings and roofs.

B. No structural member shall be cut without permission from Architect.

C. Patch around openings to match adjacent construction.

D. After the final waterproofing membrane has been installed, roofs may be cut only with written permission by the Architect.

3.6 CLEANING

A. Dirt and refuse resulting from the performance of the work shall be removed from the premises as required to prevent accumulation. The Plumbing Contractor shall cooperate in maintaining reasonably clean premises at all times.

B. Immediately prior to the final inspection, the Plumbing Contractor shall clean material and equipment installed under the Plumbing Contract. Dirt, dust, plaster, stains, and foreign matter shall be removed from surfaces including components internal to equipment. Damaged finishes shall be touched-up and restored to their original condition.

3.7 SUBSTANTIAL COMPLETION REVIEW

A. Prior to requesting inspection for "CERTIFICATE OF SUBSTANTIAL COMPLETION", the Contractor shall complete the following items:

1. Submit complete Operation and Maintenance Manuals.
2. Submit complete Record Drawings.
3. Start-up testing of systems.
4. Removal of temporary facilities from the site.
5. Comply with requirements for Substantial Completion in the "General Conditions".

B. The Contractor shall request in writing a review for Substantial Completion. The Contractor shall give the Architect/Engineer at least seven (7) days notice prior to the review.

C. The Contractor's written request shall state that the Contractor has complied with the requirements for Substantial Completion.

D. Upon receipt of a request for review, the Architect/Engineer will either proceed with the review or advise the Contractor of unfulfilled requirements.

E. If the Contractor requests a site visit for Substantial Completion review prior to completing the above mentioned items, He shall reimburse the Architect/Engineer for time and expenses incurred for the visit.

F. Upon completion of the review, the Architect/Engineer will prepare a "final list" of outstanding items to be completed or corrected for final acceptance.

G. Omissions on the "final list" shall not relieve the Contractor from the requirements of the Contract Documents.

H. Prior to requesting a final review, the Contractor shall submit a copy of the final list of items to be completed or corrected. He shall state in writing that each item has been completed, resolved for acceptance or the reason it has not been completed.

END OF SECTION

TABLE 1: PLUMBING SPECIFICATION SHOP DRAWING SUBMITTAL REQUIREMENTS

SPECIFICATION NUMBER/TITLE		CODE DESIGNATION
220010	General Plumbing Requirements	NONE
220015	Coordination	NONE
220500	Common Work Results For Plumbing	A, B, G, M
220513	Common Motor Requirements For Plumbing Equipment	B
220515	Basic Piping Materials And Methods	B, G
220519	Meters And Gauges For Plumbing Piping	B, H
220523	General-Duty Valves For Plumbing Piping	B
220529	Hangers And Supports For Plumbing Piping	B, F, G, H
220553	Identification For Plumbing Piping & Equipment	B, L, M
220700	Plumbing Insulation	B, M
221100	Water Distribution Piping & Specialties	B, G, H
221111	Mechanically Joined Plumbing Piping Systems	B, G, H
221123	Domestic Water Pumps	A, B, C, E
221300	Sanitary Drainage & Vent Piping & Specialties	B
221400	Storm Drainage Piping & Specialties	B
223300	Electric Domestic Water Heaters	B, C, E, F, H, K
224000	Plumbing Fixtures	B, E, N
227000	Natural Gas Systems	A, B, C, D, F, G
227010	Mechanically Joined Natural Gas Piping Systems	B, F, H, N

CODED LEGEND

A	Shop Drawings
B	Product Data and equipment weights
C	Performance Data, Curves, Certificates and Test Data
D	Coordination Drawings
E	Wiring Diagrams and short circuit current ratings
F	Installation Instructions
G	Welder's Certificates
H	Certificates
I	Calculations
J	Special Inspections
K	Special Warranties
L	Material Samples
M	Schedules
N	Recommended Spare Parts List

TABLE 2: SPARE PARTS REQUIREMENTS FOR PLUMBING EQUIPMENT

SECTION NUMBER		RECEIVED/DATE/INITIAL
221100	Water Distribution Piping & Specialties	_____
221111	Mechanically Joined Plumbing Piping Systems	_____
224000	Plumbing Fixtures	_____
221123	Domestic Water Pumps	_____
227000	Natural Gas Systems	_____

_____
Owner's Signature

TABLE 3: SPECIAL WARRANTY REQUIREMENTS FOR PLUMBING EQUIPMENT

SECTION NUMBER		RECEIVED/DATE/INITIAL
223300	Electric Domestic Water Heaters	_____

TABLE 5: PLUMBING SPECIFICATION OPERATION AND MAINTENANCE SUBMITTAL REQUIREMENTS

SPECIFICATION NUMBER/TITLE		CODE DESIGNATION
220500	Common Work Results For Plumbing	B
220513	Common Motor Requirements For Plumbing Equipment	B
220515	Basic Piping Materials And Methods	B
220519	Meters And Gauges For Plumbing Piping	B, G, I
220523	General-Duty Valves For Plumbing Piping	B, H, I
220529	Hangers And Supports For Plumbing Piping	B
220553	Identification For Plumbing Piping & Equipment	B
220700	Plumbing Insulation	B
221100	Water Distribution Piping & Specialties	A, B, F, H, I
221111	Mechanically Joined Plumbing Piping Systems	A, B, F, H, I
221123	Domestic Water Pumps	B, C, D, E, G, H, I
221300	Sanitary Drainage & Vent Piping & Specialties	A, B, F
221400	Storm Drainage Piping & Specialties	A, B, F
223300	Electric Domestic Water Heaters	B, C, D, E, G, H, I
224000	Plumbing Fixtures	B, E, H, I
227000	Natural Gas Systems	A, B, C, H
227010	Mechanically Joined Natural Gas Piping Systems	B, F, H

CODED LEGEND

A	As-Built Drawings
B	Product Data
C	Performance Data, Capacities, Curves and Certificates
D	Wiring Diagrams
E	Operating Instructions
F	Test Reports
G	Warranties
H	Recommended Spare Parts List
I	Service and Maintenance Instructions

SUBSTITUTION REQUEST FORM

To Project Engineer: _____ Request # (GC Determined): _____

Project Name: _____

Project No/Phase: _____ Date: _____

Specification Title: _____

Section Number: _____ Page: _____ Article/Paragraph: _____

Proposed Substitution: _____

_____

Manufacturer: _____ Model No.: _____

Address: _____ Phone: _____

History: ☐ New product ☐ 1-4 years old ☐ 5-10 years old ☐ More than 10 years old

Differences between proposed substitution and specified Work: _____

_____

☐ Point-by-point comparative data attached – REQUIRED BY ENGINEER
Comparative data may include but not be limited to performance, certifications, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements. Include all information necessary for an evaluation.

Supporting Data Attached: ☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐ Other: _____

Reason for not providing specified item: _____

_____

Similar Installation:
Project: _____ Architect: _____

Address: _____ Owner: _____

_____ Date Installed: _____

Proposed substitution affects other parts of Work: ☐ No ☐ Yes; explain: _____

_____

_____

Substitution Certification Statement:

Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner that the:

A. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
B. Proposed substitution is consistent with the Contract Documents and will produce indicated results.
C. Proposed substitution does not affect dimensions and functional clearances.
D. Proposed substitution has received necessary approvals of authorities having jurisdiction.
E. Same warranty will be furnished for proposed substitution as for specified Work.
F. Same maintenance service and source of replacement parts, as applicable, is available.
G. Proposed substitution will not adversely affect other trades or delay construction schedule.
H. Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitting Contractor	Date	Company

Manufacturer's Certification of Equal Quality:

I _____ represent the manufacturer of the Proposed Substitution item and hereby certify and warrant to Architect, Engineer, and Owner that the function and quality of the Proposed Substitution meets or exceeds the Specified Item.

Manufacturer's Representative	Date	Company

Engineer Review and Recommendation Section

Recommend Acceptance ☐ Yes ☐ No

Additional Comments: ☐ Attached ☐ None

Acceptance Section:

Contractor Acceptance Signature	Date	Company
Owner Acceptance Signature	Date	Company
Architect Acceptance Signature	Date	Company
Engineer Acceptance Signature	Date	Company

SECTION 220015 - COORDINATION

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section specifies the basic requirements for electrical components which are an integral part of packaged plumbing equipment. These components include, but are not limited to factory furnished motors, starters, and disconnect switches furnished as an integral part of packaged plumbing equipment.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for plumbing equipment are scheduled on the Drawings.

C. System shall be complete and operational with power and control wiring provided to meet the design intent shown on the drawings and specified within the specification sections.

1.2 SUBMITTALS

A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification Sections.

1.3 QUALITY ASSURANCE

A. Electrical components and materials shall be UL labeled.

B. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of this Section and Division 26.

PART 2 - PRODUCTS AND MATERIALS

2.1 GENERAL

A. The Contractors shall provide all motors, starters, disconnects, wire, conduit, etc. as specified in the Construction Documents. If, however, the Plumbing Contractor furnishes a piece of equipment requiring a different motor, starter, disconnect, wire size, etc. than what is shown and/or intended on the Construction Documents, the Plumbing Contractor shall coordinate the requirements with any other Contractor and shall be responsible for any additional cost incurred by any other Contractor that is associated with installing the different equipment and related accessories for proper working condition.

B. Refer to Division 26, "Common Work Results for Electrical" for specification of motor connections

C. Refer to Division 26, "Enclosed Switches and Circuit Breakers" for specification of disconnect switches.

PART 3 - EXECUTION

3.1 CONTRACTOR COORDINATION

A. Unless otherwise indicated, all motors, equipment, controls, etc. shall be furnished, set in place and wired in accordance with Table 1. Any items not listed but shown on the drawings shall be considered part of the Contract Documents and brought to the attention of the Architect.

B. The General Contractor is the central authority governing the total responsibility of all trade contractors. Therefore, deviations and clarifications of this schedule are permitted provided the General Contractor assumes responsibility to coordinate the trade contractors different than as indicated herein. If deviations or clarifications to this schedule are implemented, submit a record copy to the Engineer.

TABLE 1: ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

ITEM	FURN BY	SET BY	POWER WIRING	CONTROL WIRING
Equipment motors	DIV 22	DIV 22	DIV 26	---
Loose motor starters, disconnect switches, thermal overloads and heaters.	DIV 26	DIV 26	DIV 26	DIV 23
Thermostats (line voltage)	DIV 22	DIV 22	DIV 26	---
Motor and solenoid operated valves	DIV 22	DIV 22	DIV 23	DIV 23

DIV 22 = Plumbing Contractor
DIV 26 = Electrical Contractor
DIV 23 = Building Automation System Contractor, refer to Division 23 Section "Direct-Digital Control for HVAC".

END OF SECTION

SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with Plumbing installations as follows:

1. Access panels and doors in walls, ceilings, and floors for access to Plumbing materials and equipment.
2. Plumbing equipment nameplate data.
3. Concrete for bases and housekeeping pads.
4. Non-shrink grout for equipment installations.
5. Sleeves for Plumbing penetrations.
6. Miscellaneous metals for support of Plumbing materials and equipment.
7. Wood grounds, nailers, blocking, fasteners, and anchorage for support of Plumbing materials and equipment.
8. Joint sealers for sealing around Plumbing materials and equipment.
9. Plenum insulation for enclosure of combustible items located within fire-rated return air plenums.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 7 Section "Penetration Firestopping" for material and methods for firestopping systems.
2. Division 22 Section "Basic piping Materials and Methods" for materials and methods for mechanical sleeve seals.
3. Division 22 Section "Sanitary Drainage and Vent Piping and Specialties" for indirect drain piping and installation requirements.
4. Division 23 Section "Direct Digital Controls for HVAC" for integration with building automation system of leak detection system "Water Present" alarm.
5. Division 26 Section "Common Work Results for Electrical" required electrical devices.
6. Division 26 Sections "Enclosed Switches and Circuit Breakers" for field-installed disconnects.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 1 and Division 22 Section "General Plumbing Requirements".

1. Product data for the following products:
   a. Access panels and doors.
   b. Through and membrane-penetration firestopping systems.
   c. Joint sealers.
2. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for Plumbing materials and equipment.

3. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.
4. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.

    a. Coordinate sequencing with construction phasing and Owner occupancy specified in Division 1 Section "Summary of Work."

5. Through and Membrane Penetration Firestopping Systems Product Schedule: Submit a schedule for each piping system penetration that includes UL listing, location, wall or floor rating and installation drawing for each penetration fire stop system.

    a. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping condition, submit illustration, with modifications marked, approved by penetration firestopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.3 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

    1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.

    1. Provide UL Label on each fire-rated access door.

C. Through and Membrane Penetration Systems Installer Qualifications: A firm experienced in installing penetration firestopping systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping system products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

PART 2 - PRODUCTS AND MATERIALS

2.1 ACCESS TO EQUIPMENT

A. Manufacturer:

    1. Bar-Co., Inc.
    2. Elmdor Stoneman.
    3. JL Industries
    4. Jay R. Smith Mfg. Co.

5. Karp Associates, Inc.
6. Milcor
7. Nystrom Building Products
8. Wade
9. Zurn

B. Access Doors:

1. Provide access doors for all concealed equipment, except where above lay-in ceilings. Refer to Section "Identification for Plumbing Piping" for labeling of access doors.
2. Access doors shall be adequately sized for the devices served with a minimum size of 18 inches x 18 inches, furnished by the respective Contractor or Subcontractor and installed by the General Contractor.
3. Access doors must be of the proper construction for type of construction where installed.
4. The exact location of all access doors shall be verified with the Architect prior to installation.
5. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
6. Frames: 16-gauge steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.

    a. For installation in masonry, concrete, ceramic tile, or wood paneling: 1-inch-wide exposed perimeter flange and adjustable metal masonry anchors.
    b. For installation in gypsum wallboard or plaster: perforated flanges with wallboard bead.
    c. For installation in full-bed plaster applications: galvanized, expanded metal lath and exposed casing bead, welded to perimeter of frame.

7. Flush Panel Doors: 14-gauge sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.

    a. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.

8. Locking Devices: Flush, screwdriver-operated cam locks.

2.2 PLUMBING EQUIPMENT NAMEPLATE DATA

A. For each piece of power operated Plumbing equipment, provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance's, and similar essential data. Locate nameplates in an accessible location.

2.3 CONCRETE EQUIPMENT BASES/HOUSEKEEPING PADS

A. Provide concrete equipment bases and housekeeping pads for various pieces of floor mounted Plumbing equipment.. Concrete equipment bases/housekeeping pads shall generally conform to the shape of the piece of equipment it serves with a minimum 4" margin around the equipment and supports.

B. Form concrete equipment bases and housekeeping pads using framing lumber or steel channel with form release agent. Chamfer top edges and corners. Trowel tops and sides of each base/pad to a smooth finish, equal to that of the floors.

C. Concrete equipment bases and housekeeping pads shall be made of a minimum 28 day, 4000 psi concrete conforming to American Concrete Institute Standard Building Code for Reinforced Concrete (ACI 318-99) and the latest applicable recommendations of the ACI standard practice manual. Concrete shall be composed of cement conforming to ASTM C 150 Type I, aggregate conforming to ASTM C33, and potable water. All exposed exterior concrete shall contain 5 to 7 percent air entrainment.

D. Unless otherwise specified or shown on the structural drawings, reinforce equipment bases and housekeeping pads with No. 4 reinforcing bars conforming to ASTM A 615 or 6x6 – W2.9 x W2.9 welded wire mesh conforming to ASTM A185. Reinforcing bars shall be placed 24" on center with a minimum of two bars each direction.

E. Provide galvanized anchor bolts for all equipment placed on concrete equipment bases and housekeeping pads or on concrete slabs. Anchor bolts size, number and placement shall be as recommended by the Manufacturer of the equipment.

F. Concrete equipment bases and housekeeping pads shall have minimum heights in accordance with the following table:

Equipment	Minimum Height
Water Heaters, and Equipment Less than or equal to 20 tons and Other Equipment Not Listed – Note 1	3-1/2"

NOTES:

1. Height of equipment bases applies to equipment installed on slab-on-grade. For equipment installed on floors above grade and/or roof, reference the drawings.

2.4 GROUT

A. Provide nonshrink, nonmetallic grout conforming to ASTM C 1107, Grade B, in premixed and factory-packaged containers.

B. Grout shall have post-hardening, volume-adjusting, dry, non-staining, non-corrosive, non-gaseous, hydraulic-cement characteristics and shall be as recommended by manufacturer for interior and exterior applications.

C. Grout shall have 5,000 psi, 28-day compressive strength design mix.

2.5 PENETRATIONS

A. Sleeves:

1. Steel Sleeves: Schedule 40 galvanized, welded steel pipe, ASTM A-53 grade A or 12 gauge (0.1084 inches) welded galvanized steel formed to a true circle concentric to the pipe.
2. Sheet-Metal Sleeves: 10 gauge (0.1382 inches), galvanized steel, round tube closed with welded longitudinal joint.

B. Frames for rectangular openings attached to forms and of a maximum dimension established by the Architect. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, provide 18 gauge (0.052 inches) welded galvanized steel. For sleeve

cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, provide 10 gauge (0.1382 inches) welded galvanized steel. Notify the General Contractor or Architect before installing any box openings not shown on the Architectural or Structural Drawings.

C. Box Frames: Frames for rectangular openings shall be of welded 12 gauge steel attached to forms and of a maximum dimension established by the Architect. Contractor shall notify the General Contractor or Architect before installing any box openings not shown on the Architectural or Structural Drawings.

2.6 DRIP PANS

A. Drip pans for pipes in protected areas shall be 20-gauge galvanized steel with 2" lapped and soldered joints. Drip pan shall have a depth of 2" and a width of 6" in addition to the diameter of the associated pipe. Provide 3/4" galvanized pipe with male NPT outlet at low point of drip pan.

B. Drip pan supports shall be ¼" X 2" galvanized bar stock welded to the drip pan without holes.

2.7 MISCELLANEOUS METALS

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold-Formed Steel Tubing: ASTM A 500.

C. Hot-Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Fasteners: Zinc-coated, type, grade, and class as required.

2.8 MISCELLANEOUS LUMBER

A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.

B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less that 15/32 inches.

2.9 JOINT SEALERS

A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

B. Colors: As selected by the Architect from manufacturer's standard colors.

C. Elastomeric Joint Sealers: Provide the following types:

1. One-part, nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer. Provide one of the following:

    a. "Dow Corning 790," Dow Corning Corp.
    b. "Silglaze II SCS 2801," General Electric Co.
    c. "Silpruf SCS 2000," General Electric Co.
    d. "864," Pecora Corp.
    e. "Rhodia 5C," Rhone-Poulenc, Inc.
    f. "Spectrem 1," Tremco, Inc.
    g. "Spectrem 2," Tremco, Inc.
    h. "Dow Corning 795," Dow Corning Corp.
    i. "Rhodia 7B," Rhone-Poulenc, Inc.
    j. "Rhodia 7S," Rhone-Poulenc, Inc.
    k. "Omniseal," Sonneborn Building Products Div.

2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, metal or porcelain plumbing fixtures and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes. Provide one of the following:

    a. "Dow Corning 786," Dow Corning Corp.
    b. "Sanitary 1700," General Electric Co.
    c. "898 Silicone Sanitary Sealant," Pecora Corp.

D. Acrylic-Emulsion Sealants: One-part, nonsag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent. Provide one of the following:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. "Chem-Calk 600," Bostik Construction Products Div.
    b. "AC-20," Pecora Corp.
    c. "Sonolac," Sonneborn Building Products Div.
    d. "Tremflex 834," Tremco, Inc.

2.10 PLENUM INSULATION

A. General: Combustible materials including, but not limited to, plastic pipe and plastic-coated cables that do not meet the minimum combustibility requirements of the applicable building codes may be installed in fire-rated return air plenums when enclosed within high-temperature insulation blanket where approved by the authority having jurisdiction.

B. Material: FyreWrap 0.5 Plenum Insulation, ETS Schaefer Plenumshield Blanket, or equivalent utilizing light weight, high temperature blanket enhanced for biosolubility. The encapsulating material shall be aluminum foil with fiberglass reinforcing scrim covering.

C. Certification: Plenum insulation shall have an encapsulated flame spread rating less than 25 and a smoke developed rating of less than 50. The product shall be UL 1887 (Modified) listed, certified by ASTM E-136 for Non-combustibility and ASTM E-84/UL 723 for Surface Burning Characteristics.

D. Physical Properties: Plenum insulation shall be single ½" layer with a density of 6 to 8 pounds per cubic foot.

2.11 FIRESTOPPING

A. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with UL 2079 or ASTM E 814, or other NRTL acceptable to AHJ. Manufactured by:

1. Hilti
2. RectorSeal
3. Specified Technologies Inc.,
4. United States Gypsum Company
5. 3M Corp.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install plenum insulation,access doors and sealants in accordance with manufacturer's installation instructions.

3.2 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

B. Adjust hardware and panels after installation for proper operation.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS "Structural Welding Code."

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor Plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.5 PREPARATION FOR JOINT SEALERS

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.6 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

3.7 PENETRATIONS:

A. New Construction:

1. Coordinate with Divisions 03 and 04 for installation of sleeves and sleeve seals integrally in cast-in-place, precast, and masonry walls and horizontal slabs where indicated on the Drawings or as required to support piping or ductwork penetrations.

B. Construction in Existing Facilities:

1. Saw cut or core drill existing walls and slabs to install sleeves and sleeve seals in existing facilities. Do not cut or drill any walls or slabs without first coordinating with, and receiving approval from, the Architect, Owner, or both. Seal sleeves and sleeve seals into concrete walls or slabs with a waterproof non-shrink grout acceptable to the Architect.

C. Provide sleeves and/or box frames for openings in all concrete and masonry construction and fire or smoke partitions, for all mechanical work that passes through such construction; Coordinate with other trades and Divisions to dimension and lay out all such openings.

D. The General Contractor will provide only those openings specifically indicated on the Architectural or Structural Drawings as being provided under the General Contractor's work.

E. The cutting of new or existing construction shall not be permitted except by written approval of the Architect.

F. Floor sleeves shall be fitted with means for attachment to forms and shall be of length to extend at least two inches above the floor level.

G. Cut sleeves to length for mounting flush with both surfaces of walls.

H. Extend sleeves installed in floors 2 inches above finished floor level.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

J. Seal space outside of sleeves with approved joint compound for penetrations of gypsum board assemblies.

3.8 DRIP PANS

A. Provide drip pans in locations indicated on drawings.

B. Provide drip pans for piping directly above a two hour rated ceiling of an elevator machine room.

C. Provide drip pans, only with written approval obtained prior to installation, installed beneath piping above electrical rooms, telecom rooms, data rooms, servers or any other protected area not clearly indicated by drawings.

D. Provide drip pan supports every 4'-0". Provide ¼" galvanized threaded rods through bar stock on each side of the drip pan and attached with 2 nuts per rod. Attach rods to structure with MSS SP-58 compliant components.

E. Connect ¾" type "L" copper indirect drain line to drip pan outlet. Route and discharge to receptor with air gap outside of the protected area.

END OF SECTION

SECTION 220515 - BASIC PIPING MATERIALS AND METHODS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section specifies piping materials and installation methods common to more than one Section of Division 22 and includes joining materials, piping specialties and basic piping installation instructions.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "Common Work Results for Plumbing," for materials and methods for sleeve materials.

1.2 DEFINITIONS

A. Lead Free: Refers to the wetted surface of pipe, fittings and fixtures in potable water systems that have a weighted average lead content ≤0.25% per Safe Drinking Water Act as amended January 4th 2011 Section 1417.

1.3 SUBMITTALS

A. Refer to Division 1 and Division 22 Section "General Plumbing Requirements" for administrative and procedural requirements for submittals.

B. Product Data: Submit product data on the following items:

1. Escutcheons
2. Dielectric Unions (Only for use with Natural Gas Systems)
3. Dielectric Waterway Fittings
4. Dielectric Flanges and Flange Kits
5. Wall Pipes
6. Strainers

C. Quality Control Submittals:

1. Submit welders' certificates specified in Quality Assurance below.

D. Submit certification that specialties and fittings for domestic water distribution comply with NSF 61 Annex G and / or NSF 372.

E. Submit a schedule of dissimilar metal joints and dielectric waterway fittings, unions, flanges or flange kits. Include joint type materials, connection method and proposed dielectric waterway fittings, unions and flanges to isolate dissimilar metals. Include minimum and maximum torque requirements for flange connections to valves. Refer to the individual piping system specification sections in Division 22 for specifications for piping materials and fittings relative to that particular system and additional requirements.

F. Submit certification that fittings and specialties are manufactured in plants located in the United States or certified that they comply with applicable ANSI and ASTM standards.

1.4 QUALITY ASSURANCE

A. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

B. Welding procedures and testing shall comply with ANSI Standard B31.9 - Standard Code for Building Services Piping and The American Welding Society, Welding Handbook.

C. Soldering and Brazing procedures shall conform to ANSI B9.1 Standard Safety Code for Plumbing Refrigeration.

D. Pipe specialties and fittings shall be manufactured in plants located in the United States or certified to meet the specified ASTM and ANSI standards.

E. Comply with NSF 61 Annex G and / or NSF 372 for wetted surfaces of specialties and fittings containing no more than 0.25% lead by weight for domestic water distribution.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide piping materials and specialties from one of the following:

1. Pipe Escutcheons:

    a. AWI Manufacturing.
    b. Keeney Manufacturing Company
    c. Wal-Rich Corp.
    d. Jones Stephens Corp.

2. Dielectric Waterway Fittings:
    a. Grinnell Mechanical Products; Tyco Fire Products LP
    b. Precision Plumbing Products, Inc.

3. Dielectric Unions:

    a. JOMAR International
    b. Smith Cooper International
    c. Watts Regulator Co.
    d. Zurn Industries

4. Dielectric Flanges and Flange Kits:

    a. Calpico, Inc.
    b. FMC Technologies
    c. Pipeline Seal & Insulator, Inc.
    d. Tampa Rubber and Gasket Co., inc.
    e. Watts Industries Inc.; Water Products Div.

f. Zurn Industries, Inc.; Wilkins Div.

5. Strainers:

a. Armstrong Machine Works.
b. Hoffman Specialty ITT; Fluid Handling Div.
c. MEPCO
d. Metraflex Co.
e. Mueller Steam Specialties.
f. Nicholson Steam
g. RP&C Valve, Division of Conbraco Ind.
h. Spirax Sarco.
i. Watts Regulator Co.

6. Wall Pipes

a. Josam Mfg. Co.
b. Smith (Jay R) Mfg. Co.
c. Tyler Pipe/Wade Div.; Subs. of Tyler Corp.
d. Watts Industries, Inc.
e. Zurn Industries, Inc.; Hydromechanics Div.

2.2 PIPE AND FITTINGS

A. Refer to the individual piping system specification sections in Division 22 for specifications on piping and fittings relative to that particular system.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 Piping Sections for special joining materials not listed below.

B. Welding Materials: AWS D10.12; Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

C. Brazing Materials: AWS A5.8; Comply with SFA-5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials appropriate for the materials being joined.

D. Soldering Materials: ASTM B32; Refer to individual piping system specifications for solder appropriate for each respective system.

E. Gaskets for Flanged Joints: ASME B16.21; Gasket material shall be full-faced for cast-iron flanges and raised-face for steel flanges. Select materials to suit the service of the piping system in which installed and which conform to their respective ANSI Standard (A21.11, B16.20, or B16.21). Provide materials that will not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

2.4 PIPING SPECIALTIES

A. Escutcheons: Chrome-plated, stamped steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit pipe outside diameter, or outside of pipe insulation where pipe is insulated. Outside diameter shall completely cover the opening in floors, walls, or ceilings.

B. Unions:

1. Malleable-iron, Class 150 for low pressure service and class 300 for high pressure service; hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.
2. Bronze, Class 125, with lead free cast bronze body meeting ASTM B584, for low pressure service and class 250 for high pressure service; hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; solder or female threaded ends.

C. Dielectric Unions: Factory-fabricated with lead free cast bronze body meeting ASTM B584 and galvanized steel body with plastic dielectric gasket, class 125 for low pressure service and class 250 for high pressure service, and appropriate end connections for the pipe materials in which installed (screwed or soldered) to effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

D. Dielectric Waterway Fittings: Electroplated steel or brass nipple, with an inert and non-corrosive, thermoplastic lining.

E. Dielectric Flanges and Flange Kits:

1. Full faced gasket with same outside diameter and bolt hole arrangement as the flange. Pressure rating of 200psi for low pressure service and 400 psi for high pressure service at a continuous operating temperature of 180F.
2. Steel washers, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves.
3. Lead free cast bronze meeting ASTM B584, class 125 solder type or cast iron class 125 threaded type for low pressure service and bronze class 250 solder type or cast iron class 250 threaded type for high pressure service.

F. Y-Type Strainers: Provide strainers full line size of connecting piping, with ends matching piping system materials. Screens for 4" and smaller shall be Type 304 stainless steel mesh with 0.062" perforations and screens for 5" and larger shall be Type 304 stainless steel, with 0.125" perforations.

1. For low pressure applications, cast iron strainers shall have 125 psi working pressure rating and cast bronze strainers shall have 150 psi working pressure rating. For high pressure applications, cast iron strainers shall have 250 psi working pressure rating and cast bronze strainers shall have 300 psi working pressure rating.
2. Solder Ends, 2" and Smaller: Lead free cast bronze body meeting ASTM B584, screwed screen retainer with centered blowdown fitted with pipe plug.
3. Flanged Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

G. Sleeves:

1. Sleeve: Refer to Division 22 Section "Common Work Results for Plumbing" for sleeve materials.

2.5 WALL PIPES

A. Cast-iron sleeve with integral clamping flange with clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

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

3.2 PREPARATION

A. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

3.3 INSTALLATIONS

A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.

B. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated otherwise.

C. Install piping free of sags and bends and with ample space between piping to permit proper insulation applications.

D. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.

E. Install horizontal piping as high as possible allowing for specified slope and coordination with other components. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

F. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

G. Support piping from structure. Do not support piping from ceilings, equipment, ductwork, conduit and other non-structural elements.

H. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4" ball valve, and short 3/4" threaded nipple and cap.

I. Verify final equipment locations for roughing in.

3.4 PIPING PROTECTION

A. Protect piping during construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

3.5 PENETRATIONS

A. Plumbing penetrations occur when piping penetrate concrete slabs, concrete or masonry walls, or fire / smoke rated floor and wall assemblies.

B. Above Grade Concrete or Masonry Penetrations

1. Provide sleeves for pipes passing through above grade concrete or masonry walls, concrete floor or roof slabs. Sleeves are not required for core drilled holes in existing masonry walls, concrete floors or roofs. Provide sleeves as follows:

    a. Provide schedule 40 galvanized steel pipe for sleeves smaller than 6 inches in diameter.
    b. Provide galvanized sheet metal for sleeves 6 inches in diameter and larger, thickness shall be 10 gauge (0.1382 inches).
    c. Provide welded galvanized sheet metal for rectangular sleeves with the following minimum metal thickness:

        1) For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 18 gauge (0.052 inches).
        2) For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 10 gauge (0.1382 inches).

    d. Schedule 40 PVC pipe sleeves are acceptable for use in areas without return air plenums.

2. Extend pipe insulation for insulated pipe through floor, wall and roof penetrations, including fire rated walls and floors. The vapor barrier shall be maintained. Size sleeve for a minimum of 1" annular clear space between inside of sleeve and outside of insulation.
3. Seal elevated floor, exterior wall and roof penetrations watertight and weathertight with non-shrink, non-hardening commercial sealant. Pack with mineral wool and seal both ends with minimum of ½" of sealant.

C. Elevated Floor Penetrations of Waterproof Membrane:

1. Provide cast-iron wall pipes for sleeves, extend top of wall pipe minimum 1" above finish floor. Size wall pipe for minimum ½" annular space between pipe and wall pipe.
2. Extend pipe insulation for insulated pipe through wall pipe. The vapor barrier shall be maintained. Size wall pipe for a minimum of 1" annular clear space between inside of sleeve and outside of insulation.

3. Pack with mineral wool and seal both ends with minimum of ½" of waterproof sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.
4. Secure waterproof membrane flashing between clamping flange and clamping ring. Comply with requirements for flashing specified in Division 7 Section "Sheet Metal Flashing and Trim."

5. Extend bottom of wall pipe below floor slab as required and secure underdeck clamp to hold wall pipe rigidly in place.

D. Interior Foundation Penetrations: Provide sleeves for horizontal pipe passing through or under foundation. Sleeves shall be cast iron soil pipe two nominal pipe sizes larger than the pipe served.

E. Concrete Slab on Grade Penetrations:

1. Provide schedule 40 PVC pipe sleeves for vertical pressure pipe passing through concrete slab on grade. Sleeves shall be one nominal pipe size larger than the pipe served and two pipe sizes larger than pipe served for ductile iron pipes with restraining rods. Seal water-tight with silicone caulk.
2. Provide ½" thick cellular foam insulation around perimeter of non-pressure pipe passing thru concrete slab on grade. Insulation shall extend to 2" above and below the concrete slab.

F. Interior Penetrations of Non-Fire-Rated Walls: Seal annular space between sleeve and pipe or duct, using joint sealant appropriate for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of ½" of sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.

1. Extend pipe insulation for insulated pipe through sleeve. The vapor barrier shall be maintained. Size sleeve for a minimum of 1" annular clear space between inside of sleeve and outside of insulation.

G. Exterior Wall Penetrations: Seal annular space between sleeve and pipe or duct, using joint sealant appropriate for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of ½" of waterproof sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.

1. Extend pipe insulation for insulated pipe through sleeve. The vapor barrier shall be maintained. Size sleeve for a minimum of 1" annular clear space between inside of sleeve and outside of insulation.

H. Fire / Smoke Rated Floor and Wall Assemblies: Seal around penetrations of fire rated assemblies to maintain fire resistance rating of fire-rated assemblies. Coordinate fire ratings and locations with the architectural drawings. Install sealants in compliance with the manufacturer's UL listing. Refer to Division 22 Section "Common Work Results for Plumbing" for firestoppings and materials.

3.6 FITTINGS AND SPECIALTIES

A. Use fittings for all changes in direction and all branch connections.

B. Remake leaking joints using new materials.

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

D. Install strainers on the supply side of each control valve, pressure reducing or regulating valve, solenoid valve, mixing valve, backflow preventer and elsewhere as indicated.

E. Install unions at the final connection to each piece of equipment adjacent to each isolation valve or valve assembly for connections 2" and smaller. Install unions where indicated elsewhere on the drawings.

F. Install flanges at the final connection to each piece of equipment, adjacent to each isolation valve or valve assembly in piping 2-1/2" and larger. Install flanges at each valve 2-1/2" and larger.

G. Install dielectric unions for piping 2" and smaller or dielectric flanges for piping 2-1/2" and larger to connect piping materials of dissimilar metals in dry piping systems (gas) for copper or brass connected to carbon steel, cast or ductile iron.

H. Install dielectric waterway fittings for piping 2" and smaller for copper or brass pipe connections to carbon steel equipment connections.

I. Install dielectric flanges for piping 2-1/2" and larger for copper or brass pipe connections to carbon steel equipment connections, steel, ductile iron or cast iron valves and fittings.

J. Dielectric Flange Installation:

1. Provide brass nipples between the equipment connection and dielectric flange for screwed connections. Provide an iron flange for the equipment side and a bronze flange for the copper or brass piping side of the joint.
2. Provide a bronze flange for the copper or brass piping connection to a cast iron, ductile iron or steel flange.
3. Provide full face gasket with pressure rating equal to system served.
4. At each bolt provide, steel washers, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves.

3.7 JOINTS

A. Steel Pipe Joints:

1. Pipe 2" and Smaller: Thread pipe with tapered pipe threads 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. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed.
2. Pipe Larger Than 2":

    a. Weld pipe joints (except for exterior water service pipe) in accordance with ASME Code for Pressure Piping, B31.
    b. Weld pipe joints of exterior water service pipe in accordance with AWWA C206.
    c. Install flanges on all valves, apparatus, and equipment. Weld pipe flanges to pipe ends in accordance with ASME B31.9 Code for Building Services Piping. Clean flange faces and install gaskets. Tighten bolts to torque specified by manufacturer of flange and flange bolts, to provide uniform compression of gaskets.

B. Non-ferrous Pipe Joints:

1. Brazed And Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ANSI B31.9 - Standard Code for Building Services Piping and ANSI B9.1 - Standard Safety Code for Plumbing Refrigeration.
2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emory cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.

C. Joints for other piping materials are specified within the respective piping system Sections.

3.8 PIPE FIELD QUALITY CONTROL

A. Testing: Refer to individual piping system specification sections.

B. Inspection Report Form: Refer to the inspection report form at the end of this section for inspection data to be completed for each piping system. Submit completed forms to the Owner and Engineer.

END OF SECTION 220515

PLUMBING & PLUMBING PIPING SYSTEMS
INSPECTION REPORT FORM

Project Name:
Project No: _____ Contractor Project No. _____
General Contractor: _____
Inspection Date: _____Temperature: _____

System Inspected

Building: _____
Location/Description: _____
Service: _____

Inspection Results

Time of Inspection: _____
Approval to Insulate: Y N Approval to Cover in Wall: Y N
Approval to backfill Y N

Signatures

Witness: _____ Representing: _____
Witness: _____ Representing: _____
Witness: _____ Representing: _____

Remarks

_____
_____
_____
Contractor Supervisor's signature: _____

SECTION 220519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes the following types of meters and gauges:

1. Temperature gauges and fittings.
2. Pressure gauges and fittings.

1.2 SUBMITTALS

A. General: Submit the following in accordance with conditions of Contract and Division 1 Specification Sections.

1. Product data for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.
2. Product certificates signed by manufacturers of meters and gauges certifying accuracy under specified operating conditions and products' compliance with specified requirements.
3. Maintenance data for each type of meter and gauge for inclusion in Operating and Maintenance Manuals specified in Division 1 and Division 22 Section "General Plumbing Requirements."

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

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

1. Glass Tube Industrial Thermometers:

    a. H. O. Trerice Co.
    b. Marshalltown Instruments, Inc.
    c. Miljoco Corporation
    d. Weiss Instruments, Inc.
    e. Weksler Instruments Corp.
    f. Winters Instruments
2. Thermometer Wells: Same as for thermometers.
3. Pressure Gauges:

    a. Ametek, U.S. Gauge Div.
    b. Ashcroft Dresser Industries Instrument Div.
    c. Ernst Gage Co.
    d. H. O. Trerice Co.
    e. Marsh Instrument Co., Unit of General Signal.

f. Marshalltown Instruments, Inc.
g. Miljoco Corporation
h. Weiss Instruments, Inc.
i. Weksler Instruments Corp.
j. WIKA Instruments Corp.
k. Winters Instruments

4. Pressure Gauge Accessories: Same manufacturers as for pressure gauges.

2.2 THERMOMETERS, GENERAL

A. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

B. Scale range: Temperature ranges for services listed as follows:

1. Domestic Hot Water: 30 to 240 deg with 2-degree scale divisions (0 to 115 deg C with 1-degree scale divisions).
2. Domestic Cold Water: 0 to 100 deg F with 2-degree scale divisions (minus 18 to 38 deg C with 1-degree scale divisions).

2.3 GLASS TUBE INDUSTRIAL THERMOMETERS

A. Case: Die cast, aluminum finished, in baked epoxy enamel, glass front, spring secured, 9 inches long.

B. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

C. Tube: Non-red color reading, non-toxic organic spirit-filled glass tube, magnifying lens.

D. Scale: Satin-faced, nonreflective aluminum, with permanently etched markings.

E. Stem: Copper-plated steel, aluminum or brass, for separable socket, length to suit installation.

2.4 THERMOMETER WELLS

A. Thermometer Wells: Brass or stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.

2.5 PRESSURE GAUGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon-tube type, bottom connection.

B. Case: Cast aluminum or stainless steel case, glass lens, 4-1/2-inches diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:

1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

G. Liquid-Filled: Provide liquid filled gauges where specified in Part 3 of this section.

2.6 PRESSURE GAUGE ACCESSORIES

A. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

PART 3 - EXECUTION

3.1 THERMOMETERS INSTALLATION

A. Install in the following locations and elsewhere as indicated:

1. At inlet and outlet of each domestic water heater.

B. Remote-Reading Dial Thermometers: Install in control panels, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

3.2 INSTALLATION OF PRESSURE GAUGES

A. Install in the following locations, and elsewhere as indicated:

1. Provide liquid-filled gauge at suction and discharge of each pump.
2. At discharge of each pressure-reducing valve.
3. At building water service entrance.

B. Pressure Gauge Needle Valves: Install in piping tee with snubber.

END OF SECTION

SECTION 220523 - GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes general duty valves common to most plumbing water distribution piping systems.

1. Special purpose valves are specified in individual piping system specifications.

B. Contractors Option:

1. The Division 22 contractor may provide mechanically joined plumbing piping systems to connect mechanical joints, couplings, fittings, valves and related components as an option in lieu of, in whole or in part, copper sweat, brazing, threaded or flanged piping methods. Mechanically joined plumbing piping systems to connect plumbing piping where used shall be provided in compliance with specification Section 221111 "Mechanically Joined Plumbing Piping Systems".

1.2 DEFINITIONS

A. Lead Free: Refers to the wetted surface of pipe, fittings and fixtures in potable water systems that have a weighted average lead content ≤0.25% per Safe Drinking Water Act as amended January 4th, 2011 Section 1417.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product data, including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

B. Submit certification that valves for domestic water distribution comply with NSF 61 Annex G and / or NSF 372.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: Provide products specified in this section from the same manufacturer where products are available and conform to the specification requirements.

B. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the MSS Standard Practices below:

1. MSS SP 67 "Butterfly Valves"
2. MSS SP 80 "Bronze Gate, Globe, Angle and Check Valves"
3. MSS SP 110 "Ball Valves, Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends"
4. MSS SP 125 "Check Valves: Gray Iron and Ductile Iron, In-Line, Spring Loaded, Center-Guided"
5. MSS SP 139 "Copper Alloy Gate, Globe, Angle and Check Valves for Low Pressure/Low Temperature Plumbing Applications"

D. Valves shall be manufactured in plants located in the United States or certified that they comply with applicable ANSI, ASTM and MSS standards.

E. Comply with NSF 61 Annex G and / or NSF 372 for wetted surfaces of valves containing no more than 0.25% lead by weight compliance for valves for domestic water distribution.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the manufacturers listed in valve schedule.

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems.

1. Non-rising stem valves may be used where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As scheduled and required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:

1. Handwheels, fastened to valve stem, for valves other than quarter turn.
2. Lever handles, on quarter-turn valves 6-inch and smaller.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. End Connections: As indicated in the valve specifications.

1. Threads: Comply with ANSI B1.20.1.
2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.

3. Solder-Joint: Comply with ANSI B16.18.

a. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 BALL VALVES

A. Ball Valves, 2 Inch and Smaller: Meeting MSS SP 110, Class150, 600-psi CWP; two-piece construction; with ASTM B 584 cast lead free bronze, full port, blowout-proof stem and chrome-plated lead free brass ball][stainless steel ball, with replaceable "Teflon" or "TFE" seats and seals, solder ends and vinyl-covered steel handle.

2.4 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: Meeting MSS SP-67 and lead free; 200-psi CWP; lug-type body constructed of ductile iron conforming to ASTM A 536. Provide valves with field replaceable EPDM sleeve/seat, CF8M (316) stainless steel disc, 416 stainless steel stem, and EPDM O-ring stem seals. Provide lever operators, (10 position minimum), with lock and stops with locks for sizes 2-1/2 through 6 inches and gear operators with position indicator for sizes 8 inch and larger. Drill and tap valves on dead-end service or requiring additional body strength. Valves must be rated for dead end service at 150 psi with no downstream flange required.

2.5 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: Meeting MSS SP-80; Class 125, 200-psi CWP, body and cap of ASTM B 584 cast lead free bronze; with horizontal swing, Y-pattern, disc and disc holder of ASTM B 283 alloy C46400 naval brass; solder ends. Provide valves capable of being reground while the valve remains in the line.

B. Swing Check Valves, 2-1/2-Inch and Larger: Meeting MSS SP-71 and lead free; Class 125 200-psi CWP, cast iron body and bolted cap conforming to ASTM A 126, Class B; with horizontal swing, lead free bronze disc with lead free bronze disc face ring, and bronze seat ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

C. Lift Check Valves, 2-Inch and Smaller: Meeting MSS SP-139; 250-psi CWP, body, disc holder and cap of ASTM B 584 cast lead free bronze; horizontal or angle pattern, lift-type valve, with stainless steel spring, renewable "Teflon" disc and solder ends. Provide valves capable of being refitted and ground while the valve remains in the line.

PART 3 - EXECUTION

3.1 INSTALLATIONS

A. Install valves in accordance with manufacturer's installation instructions.

B. Locate valves for easy access and provide separate support where necessary. Provide access doors and fire rated access doors as required.

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install valves in horizontal piping with stem at or above the center of the pipe.

E. Install valves in a position to allow full stem movement.

F. Installation of Check Valves: Install for proper direction of flow as follows:

G. Swing Check Valves: Horizontal position with hinge pin level.

H. Lift Check Valve: With stem upright and plumb.

3.2 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-Inch and Smaller: Solder ends.
2. Copper Tube Sizes 2-1/2 Inch and Larger: flanged end.

3.3 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

A. Domestic Hot and Cold Water Service

VALVE TYPE	2" AND SMALLER	2-1/2" AND LARGER
Ball	150	
Butterfly	N/A	200
Check	125	125

3.4 VALVE SCHEDULE

A. Ball Valves (full port) – 2 inch and smaller:

MANUFACTURER	SOLDER ENDS	THREADED ENDS
Apollo (Conbraco)	77C-LF-200	77C-LF-100
Hammond	UP8311A	UP8301A
Milwaukee	UPBA-450	UPBA-400
NIBCO	S-585-80-LF	T-585-80-LF

B. Butterfly Valves (stainless steel disc) - 2-1/2 inch and larger:

MANUFACTURER	LEVER	GEAR
Apollo (Conbraco)	LD141 xx SE11*	LD141 xx SE12*
Hammond	6421-01	6421-03
Keystone	222	222
Milwaukee	ML234E	ML334E
NIBCO	LD-2022-3	LD-2022-5
Watts	XXBF-03-131-15	XXBF-03-131-1G

* xx = Valve Size

C. Swing Check Valves – 2 inch and smaller:

MANUFACTURER	SOLDER ENDS	THREADED ENDS
Apollo	161S-LF	161T-LF
Milwaukee	UP1509	UP509
NIBCO	S-413-Y-LF	T-413-Y-LF

D. Lift Check Valves – 2 inch and smaller:

MANUFACTURER	SOLDER ENDS	THREADED ENDS
Hammond	UP947	UP943
Milwaukee	UP1548T	UP548T
NIBCO	S-480-Y-LF	T-480-Y-LF

3.5 APPLICATION SCHEDULE

A. General Application: Use ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.

B. Domestic Water Systems: Use the following valve types:

1. Ball Valves, 2" and Smaller: Class 150, 600-psi CWP, with stem extension if installed in insulated pipe.,.
2. Ball Valves, 2-1/2": 200-psi CWP cast iron body.
3. Butterfly Valves, 3" and larger200-psi working pressure with cast or ductile iron body
4. Swing Check, 2-1/2" and smaller: Class 125, cast bronze, with rubber seat.
5. Check Valves, 2-1/2" and larger: Class 125, swing or wafer type as indicated.

3.6 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.7 ADJUSTING AND CLEANING

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

B. Inspect valves for leaks after piping systems have been tested and put into service, but before final adjusting and balancing. Adjust or replace packing, as required, on valves with leaks. Replace valve if leak persists.

END OF SECTION

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes the following:

1. Horizontal-piping hangers and supports.
2. Vertical-piping clamps.
3. Saddles and Shields.
4. Hanger-rod attachments.
5. Building attachments.
6. Spring hangers and supports.
7. Pre-engineered support strut systems
8. Expansion Anchors.
9. Equipment supports.
1. Pre-engineered roof supports
10. Miscellaneous materials.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "Plumbing Insulation", for high density insulation for protecting insulation vapor barrier and materials and methods for piping hanger installations.
2. Division 22 "Water Distribution Piping and Specialties", for pipe hanger types and spacing for horizontal and vertical domestic water distribution and heat traced piping of sizes and materials indicated.
3. Division 22 "Sanitary Drainage & Vent Piping and Specialties", for pipe hanger types and spacing for heat traced and cold sanitary piping of sizes and materials indicated.
4. Division 22 "Storm Drainage & Piping and Specialties", for pipe hanger types and spacing for horizontal and vertical storm drainage piping of sizes and materials indicated.

1.2 DEFINITIONS

A. Terminology used in this Section is defined in MSS SP-90.

1.3 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 01 specification Sections.

1. Product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.
2. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.
3. Welder certificates signed by Contractor certifying that welders comply with requirements specified under "Quality Assurance" Article.
4. Assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

5. Maintenance data for supports and anchors for inclusion in Operating and Maintenance Manual specified in Division 01 and Division 22 Section "General Plumbing Requirements."
6. Submit style and type of anchors to Architect or Structural Engineer for approval prior to installation.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Qualify welding processes and welding operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

C. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.

D. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Hangers, supports, and components shall be listed and labeled by a NRTL where used for fire protection piping systems. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Hangers and Supports

1. Armacell.
2. Anvil International.
3. B-Line.
4. Elite Components
5. Halfen-DEHA.
6. Hilti.
7. ERICO\Michigan Hanger Co..
8. FNW
9. Midwest.
10. National Pipe Hanger Corporation.
11. Power-Strut.
12. Truscon.
13. Unistrut.

B. Pre-Insulated Supports:

1. Calcium Silicate Shield Supports:

a. Cooper B-Line, Inc.
b. Buckaroos, Inc.

2. Pre-Engineered Thermal Hanger Inserts:

a. Armacell "Armafix".
b. Cooper B-Line, Inc.

C. Expansion Anchors:

1. Hilti.
2. Phillips.
3. Power Fasteners.
4. Rawl.

D. Pre-Engineered Roof Pipe Supports:

1. Airtec.
2. B-Line.
3. ERICO.
4. FNW
5. MIRO.
6. Roof Top Blox.

2.2 SUPPORT MATERIALS

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.
2. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

2.3 SADDLES AND SHIELDS

A. Pipe Covering Protection Saddles:

1. Sheet metal construction, meeting MSS SP-58 Type 39A or B, 100-psi average compressive strength, with center rib for pipes 12" and larger. Saddles shall cover approximately one sixth of the circumference of the pipe and shall be 12" long.

B. Pre-Insulated Supports:

1. Calcium Silicate Shield Supports:

a. Waterproofed calcium silicate conforming to ASTM C795 encased with an insulation protection shield.

2. Pre-Engineered Thermal Hanger Inserts:

a. Flexible elastomeric insulation conforming to ASTM C534, Type I with integral high density pipe support.

C. Insulation Protection Shield:

1. Sheet metal construction, meeting MSS SP-69 & SP-58 Type 40, of 18 gauge for 5-1/2" inside dimension and smaller, 16 gauge for 6-1/2" to 10-3/4" inside dimension 14 gauge

for 11-3/4" to 17" inside dimension, and 12 gauge for 18" to 28" inside dimension. Shield shall cover half of the circumference of the pipe and shall be of length indicated by manufacturer for pipe size and thickness of insulation.

a. Length: Minimum 8 inch long section at each support joint.
b. For pipes 2 inch and smaller using fiberglass or flexible elastomeric insulation without pre-insulated supports, provide insulation protection shields installed between hanger and pipe which meets the following minimum length requirements:

Pipe Size (NPS)	Insulation Thickness (inches)	Minimum Shield Length, (in) Hanger Spacing, (ft) 5	6	7	8	9	10
	0.5	5	6	8	-	-	-
	1	3	5	5	-	-	-
≤ 1	1.5	3	5	5	-	-	-
	2	3	3	3	-	-	-
	3	3	3	3	-	-	-
	0.5	8	8	11	11	12	14
	1	5	6	8	9	11	11
≤ 2	1.5	5	6	8	8	9	9
	2	5	5	6	6	8	8
	3	5	5	6	6	6	8

2. 360° Insulation Protection Shield: Shield shall cover all of the circumference of the pipe with two half circumference sections held together with bolts and nuts and shall be of length indicated by manufacturer for pipe size and thickness of insulation.

D. Hangers with pre-manufactured polymer inserts:

1. Strut-mounted pipe clamps and clevis hangers with pre-manufactured polymer inserts designed to receive butted insulation internally may be used in lieu of other insulated pipe support systems. Inserts shall support piping independent of insulation to avoid crushing. Installed system shall provide equal thermal and vapor barrier performance as systems with continuous unbroken insulation. Note: Metal shields are not required with clevis hangers of this type. Approved manufacturers include:

a. Klo-Shure.
b. Anvil.
c. Holdrite.

2.4 PRE-ENGINEERED SUPPORT STRUT SYSTEMS

A. Support strut systems shall comply with MSS SP-69, Type 59. Shop- or field-fabricated pipe-support assembly shall be made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts. Minimum 14 gauge galvanized steel with factory-punched attachment holes. Two piece straps shall be captivated at the shoulder when attachment nut is tightened and designed for use with strut system. Long or short pipe rollers designed for use with strut system, where indicated, shall attach to the channel with brackets and nuts. Provide plastic galvanic isolators for connecting bare copper pipe for use with pre-engineered support strut system where indicated. All nuts, brackets and clamps shall have the same finish as the channels.

2.5 EXPANSION ANCHORS

A. Self drilling, drilled flush or shell type.

2.6 PRE-ENGINEERED ROOF PIPE SUPPORTS

A. Nominal 4" X 4" X 12" long closed cell polyethylene blocks with embedded pre-engineered support strut or pre-engineered support struts with factory plastic bases. Two piece straps shall be captivated at the shoulder when attachment nut is tightened and designed for use with strut system. All nuts, brackets and clamps shall have the same finish as the channels.

2.7 MISCELLANEOUS MATERIALS

A. Steel Plates, Shapes, and Bars: Conforming to ASTM A 36.

B. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install hangers and supports in accordance with manufacturer's installation instructions.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

A. Install hangers, supports, clamps and attachments to support piping properly from building structure.

B. Do not attach to ceilings, equipment, ductwork, conduit and other non-structural elements such as floor and roof decking.

C. Hanger and clamps sizing:

1. Cold Piping: Provide pipe hangers sized for the pipe outside diameter plus insulation thickness.
2. Hot Piping: Provide pipe hangers sized for the pipe outside diameter.
3. Vertical Piping: Provide clamps sized for the pipe outside diameter and extend clamp through insulation.
4. Refer to Section 220700 for definition of hot and cold piping and required insulation thickness.

D. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacing complying with MSS SP-69. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.

E. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at 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 to forms. Where concrete with compressive strength less than 2,500 psi is indicated, install reinforcing bars through openings at top of inserts.

F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Provide two nuts on threaded supports to securely fasten the support.

G. Field-Fabricated, Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS D-1.1.

H. Support fire protection systems piping independently from other piping systems.

I. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

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

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ASME B31.9 Building Services Piping Code is not exceeded.

L. Insulated Piping: Comply with the following installation requirements.

1. Riser Clamps: Attach riser clamps, including spacers (if any), to piping with riser clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9. Do not use riser clamps to support horizontal, insulated piping. Seal insulation for hot piping and protect vapor barrier for cold piping as specified in Division 22 Section "Plumbing Insulation".
2. Pipe Covering Protection Saddles: Install pipe covering protection saddles where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.
3. Insulation Protection Shield: Install insulation protection shield and high density insulation where vapor barrier is indicated, sized for the insulation thickness used as specified in Division 22 Section "Plumbing Insulation".

    a. Exception for horizontal cold piping with fiberglass or flexible elastomeric insulation 2 inch and smaller: Rest fiberglass insulated pipe on hanger shield with length specified for pipe size and insulation thickness to prevent puncture or other damage as specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

4. Contractor's Option: Provide pre-engineered thermal hanger inserts for piping insulated with flexible elastomeric insulation at pipe supports for piping 2-1/2 inch and larger.
5. Contractor's Option: Provide strut-mounted pipe clamps and clevis hangers with pre-manufactured polymer inserts.

M. Pre-engineered Support Strut Systems: Channel strut systems can be used at the Contractors option in lieu of individual hangers for horizontal pipes. Space channel strut systems at the required distance for the smallest pipe supported. Provide channel gauge and hanger rods per the manufacturer's recommendations for the piping supported. Where strut systems are attached to walls, install anchor bolts per manufacturer's recommendations.

1. Uninsulated Copper Pipe: Install with plastic galvanic isolators
2. Insulated Tube or Pipe: Install with 360° insulation protection shields or pre-engineered thermal hanger-shield inserts as specified in Division 22 Section "Plumbing Insulation".

N. Expansion Anchors: Use in existing concrete, masonry or in pre-cast concrete construction.

O. Pre-Engineered Roof Pipe Supports: Set supports on an 18" X 18" x 3/16" thick roof walkway material compatible with the roof material.

3.3 INSTALLATION OF ANCHORS

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to control movement to compensators.

D. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.4 EQUIPMENT SUPPORTS

A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.

B. Grouting: Place grout under supports for piping and equipment.

3.5 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so that no roughness shows after finishing, and so that contours welded surfaces to match adjacent contours.

3.6 ADJUSTING

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

B. Touch-Up Painting: Cleaning and touch-up painting of field welds, bolted connections, and abraded areas of the shop paint on miscellaneous metal is specified in Division 9 Section "Painting".

C. For galvanized surfaces clean welds, bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. Extent of Plumbing work to be identified as required by this Section is indicated on drawings and/or specified in other Division 22 Sections.

B. Types of identification devices specified in this Section include the following:
1. Plastic Pipe Markers
2. Plastic Tape
3. Underground-Type Plastic Line Marker
4. Valve Tags
5. Valve Schedule Frames
6. Engraved Plastic-Laminate Signs
7. Plastic Equipment Markers
8. Plasticized Tags

1.2 CODES AND STANDARDS:

A. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required. Submit list of equipment to be provided with ceiling markers.

B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 1.

C. Maintenance Data: Include product data and schedules in Maintenance Manuals as specified in Division 1 and Section "General Plumbing Requirements."

PART 2 - PRODUCTS AND MATERIALS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide plumbing identification materials of one of the following:

1. Allen Systems, Inc.

2. Brady (W.H.) Co.; Signmark Div.
3. Brimar Industries, Inc.
4. Seton Name Plate Corp.

2.2 PLUMBING IDENTIFICATION MATERIALS

A. General: Provide manufacturer's standard 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.

2.3 PLASTIC PIPE MARKERS

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1

B. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1

C. 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 degrees F (52 degrees C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

D. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Laminated or bonded application of pipe marker to pipe (or insulation).
4. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

E. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:

1. Laminated or bonded application of pipe marker to pipe (or insulation).
2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2" wide; full circle at both ends of pipe marker, tape lapped 3".
3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

F. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic, or printed on pressure sensitive tape.

G. Lettering: Comply with piping system nomenclature as specified, scheduled, or shown, and abbreviate only as necessary for each application length.

H. Weather resistance: Where pipe markers shall be exposed to the weather, provide products suitable for use in weather.

2.4 PLASTIC TAPE

A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6", 2-1/2" wide tape for larger pipes.

C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.5 VALVE TAGS

A. Brass Valve Tags: Provide 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.

1. Provide 1-1/2" diameter tags, except as otherwise indicated.
2. Fill tag engraving with black enamel.

B. Valve Tag Fasteners: Provide manufacturer's standard 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.

2.6 ACCESS PANEL MARKERS

A. Access Panel Markers: Provide manufacturer's standard 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.

2.7 VALVE SCHEDULE FRAMES

A. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, complying with ASTM D 709 and Fed. Spec. L-P-387, in the sizes and thickness indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for plumbing fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.

C. Size: 1-1/2" high for single line, 2" high for two lines.

D. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

1.1 CEILING MARKERS

A. Description: Paper dot, self-adhesive with 3/4 inch diameter color coded head.

B. Color to match service of equipment or control device.

2.9 PLASTIC EQUIPMENT MARKERS

A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers. Conform to the following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.
4. Brown: Energy reclamation equipment and components.
5. Blue: Equipment and components that do not meet any of the above criteria.
6. For hazardous equipment, provide colors and designs recommended by ANSI A13.1.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and plan number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide 2-1/2" x 4" markers for control devices, and valves; and 4-1/2" x 6" for equipment.

2.10 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations and other designations used in plumbing identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of plumbing systems and equipment.

1. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

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

3.2 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow:

1. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.

B. Application: Provide piping system identification for the following systems:

1. Domestic cold water piping.
2. Domestic hot water piping.
3. Domestic hot water recirculating piping.
4. Sanitary and waste piping.
5. Storm water piping.
6. Vent piping.
7. Insulated and non-insulated storm water piping.
8. Compressed air piping.
9. Natural gas piping.

C. Location: Install pipe markers and color bands in the following locations where piping is exposed to view, concealed only by a removable ceiling system, installed in machine rooms, installed in accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations. All identification signs and markers shall be easily visible and legible. Relocate signs or markers that become visually blocked by work of others.

1. Within 5 feet of each valve and control device.
2. Within 5 feet of each branch, excluding take-offs less than 25 feet in length for fixtures; mark flow direction of each pipe at branch connection.
3. Within 5 feet where pipes pass through walls, floors or ceilings or enter non-accessible enclosures. Provide identification on each side of wall, floor or ceiling.
4. At access doors, manholes and similar access points which permit view of concealed piping.
5. Within 5 feet of major equipment items and other points of origination and termination.
6. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment where there are more than two piping systems or pieces of equipment.
7. On piping above removable acoustical ceilings.

3.3 VALVE IDENTIFICATION

A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience hose bibbs, and shut-off valves at plumbing fixtures and similar rough-in connections of end-use fixtures and units.

B. List each tagged valve in valve schedule for each piping system. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

1. Where more than one major machine room is shown for project, install mounted valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

3.4 PLUMBING EQUIPMENT IDENTIFICATION

A. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of plumbing equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:

1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Meters, gauges, thermometers and similar units.
3. Pumps
4. Water heaters.
5. Strainers, water treatment systems and similar equipment.

B. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at Installer's option.

C. Lettering Size: 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.

D. 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.

END OF SECTION

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. Extent of Plumbing insulation required by this Section is indicated on drawings and schedules, and by requirements of this Section.

B. Types of Plumbing insulation specified in this Section include the following:

1. Piping Systems Insulation:

   a. Fiberglass
   b. Flexible Elastomeric

2. Equipment Insulation:

   a. Fiberglass
   b. Flexible Elastomeric

1.2 QUALITY ASSURANCE

A. Flame/Smoke Ratings: Provide composite Plumbing 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 UL 723 or ASTM E 84 (NFPA 255) method.
   1. Exception: Industrial Plumbing insulation that will not affect life safety egress of building may have flame spread index of 75 and smoke developed index of 150.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "Hangers and Supports for Plumbing Piping," for insulation shields for protecting insulation vapor barrier and materials and methods for piping installations.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of Plumbing insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each Plumbing system requiring insulation.

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

PART 2 -
PRODUCTS AND MATERIALS

2.1 ACCEPTABLE MANUFACTURERS

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

1. Aeroflex USA, Inc.
2. Armacell LLC.
3. CertainTeed Corp.
4. Knauf Insulation
5. Johns Manville
6. K-Flex USA
7. Owens Corning

2.2 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated.

B. Flexible Elastomeric Piping Insulation: ASTM C534, Type I.

C. Jackets for Piping Insulation: ASTM C1136, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

1. PVC: One-piece, pre-molded PVC cover conforming to ASTM D1784, Johns Manville Zeston 2000 PVC or approved equivalent. Factory supplied, pre-cut insulation blanket inserts for use with PVC fitting covers are acceptable.

D. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

E. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

F. Insulation Diameters: Comply with ASTM C585 for inner and outer diameters of rigid thermal insulation.

G. Pipe, Valve and Fitting Covers: Comply with ASTM C450 for fabrication of fitting covers for pipe, valves and fittings.

H. High Density Insulation Billets:

1. Cellular Glass: ASTM C552.

2.3 EQUIPMENT INSULATION MATERIALS

A. Rigid Fiberglass Equipment Insulation: ASTM C612, Class 2.

B. Flexible Fiberglass Equipment Insulation: ASTM C553, Type I, Class B-4.

C. Flexible Elastomeric Equipment Insulation: ASTM C534, TYPE II.

D. Jacketing Material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

E. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

F. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

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

3.2 PLUMBING PIPING SYSTEM INSULATION

A. Insulation Omitted: Omit insulation on the following:

1. Chrome-plated exposed piping
2. Water Hammer Arrestors
3. Flow control valves
4. Drain lines from water coolers
5. Exterior condensate drain piping
6. Buried piping
7. Pre-insulated equipment.

B. Cold Piping:

1. Application Requirements: Insulate the following cold plumbing piping systems:

    a. Potable cold water piping.
    b. Non-potable cold water piping
    c. Potable chilled water piping.
    d. Plumbing vents within 6 lineal feet of roof outlet.
    e. Horizontal and vertical interior above-ground storm drainage piping and vertical run from roof drain to horizontal run.
    f. Horizontal and vertical interior above-ground overflow storm drainage piping and vertical run from roof drain to horizontal run. Where vertical overflow storm drainage piping from the outlet exceeds 15 feet, only insulate within 15 feet of the outlet.
    g. Condensate piping inside the building.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

    a. Fiberglass: 1" thickness.

C. Hot Piping:

1. Application Requirements: Insulate the following hot plumbing piping systems:

   a. Potable hot water piping.
   b. Potable hot water recirculation piping.

2. Insulate hot water piping systems up to 140F specified above with one of the following types and thicknesses of insulation:

   a. Fiberglass: 1" thick for pipe sizes up to and including 1-1/4", 1-1/2" thick for pipe sizes 1-1/2" and larger.]

D. P-traps:

1. Insulate P-traps receiving chilled water waste and P-traps of water coolers as described below:

   a. Flexible Elastomeric: 1/2" thick for pipe sizes up to and including 2", 1" thick for pipe sizes 2" to 6" (largest size permitted).

2. Insulate P-traps receiving hot water waste above 140F as described below:

   a. Fiberglass: 1" thickness.
   b. Flexible Elastomeric (high temp formula up to 300F): 1" thickness.

3.3 EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment:
   a. Roof drain bodies.

2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:

   a. Fiberglass: 2" thick for cold surfaces above 35 degrees F (2 degrees C) and 3" thick for surfaces 35 degrees F (2 degrees C) and lower.
   b. Flexible Elastomeric: 1" thick.

3.4 INSTALLATION OF PIPING INSULATION

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Maintain continuous thermal and vapor-retarder integrity throughout entire installation unless otherwise indicated.

C. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

D. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

E. Clean and dry pipe surfaces prior to insulating.

F. Pipe insulation:

1. Insulate all cold piping to prevent moisture condensation on exterior surfaces.
2. Provide high density insulation material under supports or pre-insulated supports. Refer to Division 22 Section "Hangers and Supports for Plumbing Piping" for pre-insulated supports.
3. Protect insulation with shields to prevent puncture or other damage. Refer to division 22 Section "Hangers & Supports for Plumbing Piping" for insulation shields.
4. High density insulation material shall extend a minimum 2 inches past the pipe shield on each side.
5. Butt insulation to hanger or riser clamp for vertical pipe. Butt pipe insulation tightly at insulation joints.
6. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints.
7. For cold pipes, apply wet coat of vapor barrier lap cement on joint and seal with 3 inch wide vapor barrier tape or band and coat all taped seams and staple penetrations with vapor barrier coating to prevent moisture ingress.

G. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves (except balancing and flow control valves), strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Butt tightly against adjoining pieces and bond with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves (except balancing and flow control valves), flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

H. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

I. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

J. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

3.5 INSTALLATION OF EQUIPMENT INSULATION

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, breechings, or stacks while hot.

E. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

F. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

G. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

H. Do not insulate cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.

3.6 EXISTING INSULATION REPAIR

A. Repair damaged sections of existing Plumbing insulation, both previously damaged or damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

3.7 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION

SECTION 221100 - WATER DISTRIBUTION PIPING AND SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes domestic cold water, hot water, and hot water recirculation piping, fittings, and specialties within the building to a point 5 feet outside the building.

B. Contractors Option:

1. The Division 22 contractor may provide mechanically joined plumbing piping systems to connect mechanical joints, couplings, fittings, valves and related components as an option in lieu of, in whole or in part, copper sweat, brazing, threaded or flanged piping methods. Mechanically joined water distribution piping systems where used shall be provided in compliance with specification Section 221111 "Mechanically Joined Plumbing Piping Systems".

C. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "General Plumbing Requirements," for trenching and backfilling materials and methods for underground piping installations.
2. Division 2 Section "Water Service Systems," for water service piping beginning from 5'-0" outside the building.
3. Division 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
4. Division 12 Section "Laboratory Casework and Fixtures," for laboratory trim installed in the casework.
5. Division 22 Section "Identification, for Plumbing Piping and Equipment" for labeling and identification of water distribution piping.
6. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations, wall penetrations and equipment pads.
7. Division 22 Section "Basic Piping Material and Methods," for materials and methods for strainers, flexible connectors, unions, dielectric unions, dielectric flanges and mechanical sleeve seals.
8. Division 22 Section "General Duty Valves for Plumbing Piping," for materials and methods for installing water distribution piping valves.
9. Division 22 Section "Hangers and Supports for Plumbing Piping," for insulation shields, materials and methods for hanging and supporting water distribution piping.
10. Division 22 Section "Plumbing Insulation," for materials and methods for insulating water distribution piping.
11. Division 22 Section "Sanitary Drainage and Vent Piping and Specialties," for material and methods for trap primer outlet piping.

12. Division 23 Section "Direct-Digital Control for HVAC" for interlock of [digital thermostatic mixing valve and] pilot operated flood control valve water shutoff alarm with facility management system.

1.2 DEFINITIONS

A. Water Distribution Pipe: A pipe within the building or on the premises that conveys water from the water service pipe or meter to the points of usage.

B. Water Service Pipe: The pipe from the water main or other source of potable water supply to the water distribution pipe of the building served.

C. Pipe sizes used in this Specification are nominal pipe size (NPS).

D. Lead Free: Refers to the wetted surface of pipe, fittings and fixtures in potable water systems that have a weighted average lead content ≤0.25% per Safe Drinking Water Act as amended January 4th 2011 Section 1417.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specifications Sections.

1. Product data for each piping specialty and valve specified.

2. Welder Certificates signed by Contractor certifying that welders comply with requirements specified in Article "Quality Assurance" below.
3. Certification of Compliance with ASME and UL fabrication requirements specified in Article "Quality Assurance" below.
4. Maintenance data for each piping specialty and valve specified for inclusion in Maintenance Manual specified in Division 1 and Division 22 Section "General Plumbing Requirements."
5. Test reports specified in Part 3 of this Section.

6. Submit certification that specialties and fittings for domestic water distribution for drinking or cooking comply with NSF 61 Annex G and / or NSF 372. The following specialties need not comply:

    a. Hose bibbs
    b. Wall and roof hydrants
    c. Emergency mixing valves

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."

B. Regulatory Requirements: Comply with the provisions of the following codes:

1. ASME B31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
2. ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications" for Qualifications for Welding Processes and Operators.

C. Comply with NSF 61 Annex G and / or NSF 372 for wetted surfaces of specialties and fittings containing no more than 0.25% lead by weight for domestic water distribution for drinking or cooking.

D. Pipe, fittings and specialties shall be manufactured in the United States or be certified to meet ASTM and ANSI standards.

1.5 SPARE PARTS

A. Maintenance Stock: Furnish one valve key for each key-operated wall hydrant, hose bibb, fixture supply, or faucet installed.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

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

1. Automatic Flow Control Valves:
    a. Flow Design, Inc., Autoflow Div
    b. Victaulic Company
    c. Calefi
2. Hose Bibbs:
    a. Lee Brass Co.
    b. Mansfield Plumbing Products
    c. Nibco, Inc.
    d. Prier, Inc.
    e. Watts Regulator Co.
    f. Woodford Mfg. Co.
3. Wall Hydrants:
    a. Josam Co.
    b. Smith (Jay R.) Mfg. Co.
    c. Prier, Inc.
    d.
    e. Watts Drainage
    f. Woodford Mfg. Co.
    g. Zurn Industries Inc., Hydromechanics Div.
4. Backflow Preventers:
    a. Febco
    b. Watts Regulator Co.
    c. Zurn Industries Inc. Wilkins Regulator Div.
5. Piston Type Water Hammer Arresters:
    a. Amtrol, Inc.
    b. Josam Co.
    c. Precision Plumbing Products, Inc.
    d. PROFLO
    e. Sioux Chief Manufacturing Co.
    f. Tyler Pipe/Wade Div.; Subs. of Tyler Corp.
    g. Watts Regulator Co.
    h. Zurn Industries, Inc. Wilkins Regulator Div.
6. Point of Use Thermostatic Mixing Valves
    a. Leonard Valve Co.

b. Powers Process Controls

7. Emergency Mixing Valves

a. Acorn Engineering Co.
b. Bradley
c. Haws Corp.
d. Lawler Manufacturing Co., Inc.
e. Leonard Valve Co.
f. Stingray Systems

8. Plumbing Pipe Support Brackets

a. Holdrite
b. PROFLO
c. Sioux Chief

9. Sanitary Roof Hydrants
a. Mapa (no substitutions)

2.2 PIPE AND TUBE MATERIALS, GENERAL

A. Pipe and Tube: Refer to Part 3, Articles "Above Ground Water Distribution Pipe and Fittings" or "Below Ground Water Distribution Pipe and Fittings", for identification of systems where the materials listed below are used.

B. Copper Tube: ASTM B88, Type L Water Tube, drawn temper.

C. Copper Tube: ASTM B88, Type K Water Tube, annealed temper.

D. Ductile-Iron Pipe: AWWA C151 or AWWA C115 ductile-iron pipe, with AWWA C104 cement-mortar lining.

E. Brass Pipe: Chrome Plated Schedule 40 ASTM B43 iron pipe size (IPS.)

2.3 FITTINGS

A. Wrought Copper Solder-Joint Fittings: ANSI B16.22, streamlined pattern.

B. Ductile-Iron Gasketed Fittings: AWWA C110 or AWWA C153, 150 psi rating, with cement mortar lining and AWWA C111 rubber gaskets.

C. Brass Fittings: Chrome plated ANSI B16, Class 125 with threaded connections.

D. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125, raised ground face, bolt holes spot faced.

E. Bronze Flanges: ANSI B16.24, Class 150, raised ground face, bolt holes spot faced.

2.4 JOINING MATERIALS

A. Solder Filler Metal: ASTM B32 Alloy Sb-5, 95-5 Tin-Antimony.

B. Brazing Filler Metals: AWS A5.8, BAg Silver.

C. Gasket Material: Thickness, material, and type suitable for fluid to be handled and design temperatures and pressures.

2.5 GENERAL-DUTY VALVES

A. General-duty valves (i.e., check, ball and butterfly valves) are specified in Division 22 Section "General Duty Valves for Plumbing Piping." Special duty valves are specified below by their generic name; refer to Part 3, Article "Valve Applications" for specific uses and applications for each valve specified.

2.6 SPECIAL DUTY VALVES

A. Automatic Flow Control Valves: 400 PSI WOG, flow regulator, with series 300 stainless steel body, series 300 stainless steel automatic pre-set flow balancing cartridge, union connection body, and threaded-end connections.

2.7 PIPING SPECIALTIES

A. Hose Connections: Hose connections shall have garden hose thread outlets conforming to ASME B1.20.7.

B. Hose Bibbs: Bronze body, renewable composition disc, tee handle, 1/2- or 3/4-inch solder inlet, hose outlet.

C. Hose Bibbs: Bronze body with chrome- or nickel-plated finish, with renewable composition disc, integral vacuum breaker, wheel handle, 1/2- or 3/4-inch solder inlet, hose outlet.

D. Recessed Nonfreeze Wall Hydrants: Cast-bronze box, with chrome-plated face, tee handle key, vacuum breaker, hinged locking cover, 3/4-inch inlet, and hose outlet. Bronze casing shall be length to suit wall thickness.

E. Roof Hydrants: As specified on the drawings.

F. Backflow Preventers: Comply with requirements of ASSE Standard 1013 and as specified on the drawings.

G. Piston Type Water Hammer Arresters: Piston type, with casing of type "L" copper tube and spun copper ends, nylon piston with two EPDM "O"rings pressure lubricated with FDA approved silicone, pressure rated for 250 psi, tested and certified in accordance with PDI Standard WH-201.

H. Point of Use Thermostatic Mixing Valves:

1. Lead free bronze or brass body meeting ASTM B584 with non-corrosive parts, tamper resistant temperature adjustment, checks, stops, other components as scheduled and meeting ASSE 1070. Valve shall be designed to fail to the cold side of the system. Maximum pressure drop shall not be exceeded for the scheduled flow rate.

I. Emergency Mixing Valves:

1. Bronze body construction meeting ASTM B584, non-corrosive parts, tamper resistant temperature adjustment, union inlets. Valve shall be designed to fail to the cold side of the

system with full cold water flow. Maximum pressure drop shall not be exceeded for the scheduled flow rate.

J. Pipe Support Brackets:

1. Sheet Stud Bracket: 20 gauge copper with nominal copper tube holes of ½" on 2" centers and holes of ¾" or 1" on 4" centers.
2. Pipe Mounted Bracket: 20 gauge copper or plastic bracket with clamps for securing copper water tube and stainless steel hose clamp for securing bracket to vertical waste and vent pipe in wall.
3. Carrier Bracket: 20 gauge copper bracket with 1" hole for supporting rough-in for flush valve copper tube and bolt slot for attaching to chair carrier.

K. Tube Suspension Clamps

1. Combination plastic supports and insulators for installing copper tube in stud walls with integral bracket for securing to stud with screws.

PART 3 - EXECUTION

1.1 INSTALLATION, GENERAL

A. Install piping, valves and specialties in accordance with manufacturer's installation instructions.

3.2 PREPARATION FOUNDATION FOR BELOW GROUND WATER DISTRIBUTION PIPE AND FITTINGS

A. Copper Tube: Provide 6" thick sand pipe bed underneath and around sides of pipe, up to middle half of the pipe. Support pipe in trench with sand bags level and true at fittings to prevent sand, gravel or debris from interfering with the brazing process. After pressure testing is complete, install bedding at fittings and install subbase. Refer to Section "General Plumbing Requirements" for bedding and subbase materials, excavation, trenching, backfill and compaction requirements.

B. Ductile Iron Pipe: Shape bottom of trench to fit bottom of pipe for 90-degrees (bottom 1/4 of the circumference). Fill unevenness with tamped sand bedding. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation. For piping with rock trench bottoms, provide sand pipe bed 6" underneath and around sides of pipe up to middle half of the pipe, including fittings. After pressure testing is complete, provide first layer of pea gravel backfill 6" above pipe, tamp backfill with mechanical tamper and install bedding at fittings and install subbase. Refer to Section "General Plumbing Requirements" for bedding and subbase materials, excavation, trenching, backfill and compaction requirements.

3.3 ABOVE GROUND WATER DISTRIBUTION PIPE AND FITTINGS

A. Install Type L, drawn copper tube with wrought copper fittings and solder joints for pipe sizes 8 inches and smaller, within the building.

B. Install chrome plated brass pipe and fittings for exposed water piping within the building where indicated on the drawings.

3.4 BELOW GROUND WATER DISTRIBUTION PIPE AND FITTINGS

A. Install Type K, soft annealed copper tube and brazed joints for pipe sizes 2 inches and smaller, with minimum number of joints, inside and outside building.

B. Install cement-lined ductile-iron pipe with rubber gasketed joints, inside and outside building, for pipe 3" and larger.

3.5 PIPING INSTALLATION

A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and branch connections.

C. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

D. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

E. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

F. Install horizontal piping as high as possible allowing for proper slope and coordination with other components. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

G. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

H. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4-inch ball valve, and short 3/4-inch threaded nipple and cap.

I. Fire Barrier Penetrations: Where pipes pass though fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity. Refer to Division 22 Section "Common Work Results for Plumbing" for special sealers and materials.

J. Exterior Wall Penetrations: Seal pipe penetrations through exterior wall constructions with sleeves packing, and sealant. Refer to Division 22 Section "Basic Piping Materials and Methods" for additional information.

K. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of Non-Fire Rated Walls and Concrete Slab on Grade Penetrations: Provide sleeves and seal pipes that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 22 Section "Basic Piping Materials and Methods" for special sealers and materials.

L. Install piping with level with no pitch.

3.6 HANGERS AND SUPPORTS

A. General: Hanger, support, insulation protection shield and anchor components and installation procedures conforming to MSS SP-58 and SP-69 are specified in Division 22 Section "Hangers and Supports for Plumbing Piping". Conform to the table below for maximum spacing of supports.

B. Pipe Attachments: Install the following:

1. Adjustable steel clevis hangers, MSS SP-69 Type 1, for individual horizontal runs.
2. Riser clamps, MSS SP-69 Type 8, for individual vertical runs. Provide copper coated riser clamps when in contact with copper tube.
3. Insulation protection shields and high density insulation at each hanger for insulated pipe as specified in Division 22 Sections "Supports and Anchors" and "Plumbing Insulation".
4. Copper coated extension split ring pipe clamp, MSS SP-69 Type 12, for individual vertical exposed runs of copper tube 2" and smaller on walls and for securing 1-1/4" to 2" copper tube inside walls and chases for battery fixtures. Secure clamp to the copper tube.

    a. Seal each joint with insulation and split ring pipe to maintain the insulation barrier. Refer to Section "Plunmbing Insulation" for requirement for maintenance of the vapor barrier and vapor barrier seal method.

5. Extension split ring pipe clamp, MSS SP-69 Type 12, for individual vertical exposed runs of stainless steel tube 2" and smaller on walls or for securing tube inside walls for connection to faucets.
6. Support copper tube in chases and walls at plumbing fixtures with plastic or copper brackets secured to structure and U-bolts sized to bare on the pipe.
7. Engineered strut support system may be provided, at the contractor's option, in lieu of individual hangers for horizontal pipes as specified in Division 22 "Hangers and Supports for Plumbing Piping". Provide two piece straps for uninsulated pipe secured to the bare pipe and provide plastic galvanic isolators for bare copper tube. Provide two piece straps and 360° insulation protection shields sized for the insulation thickness used for the pipe for all insulated pipes.
8. Secure copper tube rough-in for individual fixtures with sheet stud brackets attached to the wall studs or pipe mounting brackets attached to the fixture waste & vent pipe at each plumbing fixture.
9. Secure 1" and smaller copper water tubing in stud walls at stud penetrations with tube suspension clamps.

    a. Cut hole through non-supporting studs with a minimum 1/8" clearance around each uninsulated copper tube or insulated copper tube.
    b. Seal each joint of insulation and tube suspension clamp to maintain the insulation barrier. Refer to Division 22 "Plumbing Insulation" for requirement for maintenance of the vapor barrier similar to insulation butted against insulation inserts and vapor barrier seal method.

10. Secure copper tubes for flush valve wall mounted water closets to the chair carrier with carrier brackets.

C. Install hangers for horizontal piping with the following maximum spacing and minimum rod sizes:

Nom. Pipe Size - In.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.

Up to 3/4	5		3/8
1	6		3/8
1-1/4	7		3/8
1-1/2	8		3/8
2	8		3/8
2-1/2	9		1/2
3	12	10	1/2
4	14	12	5/8 (1/2 for copper)

1. Support vertical copper tube at each floor and in intervals not to exceed 10 feet.

D. Support water piping within 12" of each elbow or tee and for water piping 2-1/2" and larger at each valve or strainer.

E. Support water piping above the floor with pipe supports attached to the floor with anchor bolts where indicated on the drawings. Conform to the table above for maximum spacing of supports.

3.7 PIPE AND TUBE JOINT CONSTRUCTION

A. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."

B. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."

1. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts of piping specialties before soldering and brazing.
2. Fill the tubing and fittings during brazing with an inert gas (nitrogen or carbon dioxide) to prevent formation of scale.
3. Heat joints to proper and uniform temperature.

C. Threaded Joints: Conform to ASME B1.20.1, tapered pipe threads for field-cut threads. Join pipe fittings and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
2. Align threads at point of assembly.
3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

    a. Damaged Threads: Do not use pipe with corroded or damaged threads. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

D. Flanged Joints: Align flange surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

E. Joints Containing Dissimilar Metals: Provide dielectric flanges for piping 2-1/2" and larger. Provide dielectric waterway fittings for 2" and smaller. waterway fittings and flanges are specified in Section "Basic Piping Materials and Methods".

F. Joints at Valve Assemblies or Connections to Equipment: Provide unions downstream of shutoff valves at valve assemblies or equipment connections. Unions are not required at flanged connections. Unions are specified in Division 22 section "Basic Piping Materials and Methods".

3.8 SERVICE ENTRANCE

A. Extend water distribution piping to connect to water service piping, of size and in location indicated for service entrance to building. Water service piping is specified in a separate section of Division 2.

B. Underground exterior water distribution piping to be a depth as required by local conditions, in accordance with authority having jurisdiction's requirements and at depth no less than 18" below grade.

C. Install sleeve and mechanical sleeve seal at penetrations through foundation wall for watertight installation.

D. Install sleeve and caulk at penetrations through building floor for watertight installation.

E. Install shutoff valve at service entrance inside building; complete with strainer, pressure gauge, and test tee with valve.

F. Ductile-Iron Pipe: Install in accordance with AWWA C-600. Pipe below ground inside building and to a point 5 feet outside of building shall have restrained joints.

G. Copper Pipe: Install Type K, soft annealed copper tube and brazed joints, with minimum number of joints, to a point 5 feet outside of building. Install changes of direction larger than the manufacturer recommended minimum bend radius to prevent kinks in the line.

3.9 VALVE APPLICATIONS

A. General-Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shut-off duty: Use ball and butterfly valves.

3.10 INSTALLATION OF VALVES

A. Sectional Valves: Install sectional valves on each branch and riser, close to main, where branch or riser serves 2 or more plumbing fixtures or equipment connections, and elsewhere as indicated. For sectional valves 2 inches and smaller, use ball valves; for sectional valves 2-1/2 inches and larger, use ball or butterfly valves.

B. Shutoff Valves: Install shutoff valves on inlet of each plumbing equipment item, on each supply to each plumbing fixture, and elsewhere as indicated. For shutoff valves 2 inches and smaller, use ball valves; for shutoff valves 2-1/2 inches and larger, use ballor butterfly valves. Valves shall be installed in an accessible location.

C. Drain Valves: Install drain valves on each plumbing equipment item, located to drain equipment completely for service or repair. Install drain valves at the base of each riser, at low points of horizontal runs, and elsewhere as required to drain distribution piping system completely. For drain valves 2 inches and smaller, use ball valves; for drain valves 2-1/2 inches and larger, use ball or butterfly valves.

1.

D. Check Valves: Install swing check valves on discharge side of each pump and elsewhere as indicated.

E. Hose Bibbs: Install on exposed piping where indicated with vacuum breaker.

F. Wall Hydrants: Install where indicated with vacuum breaker.

G. Emergency Mixing Valves: Install where indicated on the plans with hot and cold water branch lines connecting to the mains without any shutoff valves. No other fixtures shall connect to the branch lines feeding the emergency mixing valve. Install ball valves with locking handles at the emergency mixing valve as indicated on the plans.

H. Point-of-Use Thermostatic Mixing Valve: Install valve complying with ASSE 1070 on all public lavatories and handwashing sink locations. Install valve to be accessible by maintenance staff. Set temperature limit to 110F for dual temperature faucet or 100F for single temperature faucet."

3.11 INSTALLATION OF FLOW CONTROL VALVES

A. Install automatic flow control valves in each hot water recirculating loop, and elsewhere as indicated. Install a shutoff valve and strainer upstream and a union, check valve and shutoff valve downstream of each automatic flow control valve.

B. Reports: Prepare hot water return system balancing reports signed and submit to the Architect upon completion of the project. Include the following information:

a. Valve tag number and description of location
b. Valve body size
c. Differential pressure reading from instrument in psi
d. Actual flow rate derived from the manufacturer's charts and tables for the valve size and measured differential pressure.

3.12 INSTALLATION OF PIPING SPECIALTIES

A. Install backflow preventers at each connection to mechanical equipment and systems and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected. Backflow preventers shall be installed a maximum of 5'-0" above finished floor. Install air gap fitting and pipe relief outlet drain without valves to nearest floor drain.

B. Install pressure reducing valves with inlet and outlet shutoff valves and balance cock bypass. Install pressure gauge on valve outlet. Pressure reducing valves shall be installed at maximum of 5'-0" above finished floor.

3.13 EQUIPMENT CONNECTIONS

A. Piping Runouts to Fixtures: Provide hot and cold water piping runouts to fixtures of sizes indicated, but in no case smaller than required by plumbing code.

B. Mechanical Equipment Connections: Connect hot and cold water piping system to mechanical equipment as indicated. Provide shutoff valve and union for each connection; provide drain valve on drain connection. For connections 2-1/2 inches and larger, use flanges instead of unions.

3.14 FIELD QUALITY CONTROL

A. Inspections: Inspect water distribution piping as follows:

1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.
2. During the progress of the installation, notify the plumbing official having jurisdiction at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

    a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed in after system is roughed in and prior to setting fixtures.
    b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to ensure compliance with the requirements of the plumbing code.
    c. Reinspections: Whenever the plumbing official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the plumbing official.
    d. Reports: Prepare inspection reports signed by the plumbing official and turn over to the Architect upon completion of the project.

B. Piping System Test: Test water distribution systems in accordance with the procedures of the authority having jurisdiction, or in the absence of a published procedure, as follows:

1. Test for leaks and defects all new water distribution piping systems and parts of existing systems that have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced water distribution piping until it has been tested and approved. Expose all such work for testing that has been covered or concealed before it has been tested and approved.
3. Cap and subject the piping system to a static water pressure of 50 psig above the operating pressure without exceeding the pressure rating of the piping system materials. Isolate the test source and allow to stand for 4 hours. Leaks and loss in test pressure constitute defects that must be repaired.
4. Repair all leaks and defects with new materials and retest system or portion thereof until satisfactory results are obtained.
5. Reports: Prepare inspection reports and required corrective action signed by the plumbing official and turn over to the Architect upon completion of the project.

3.15 ADJUSTING AND CLEANING

A. Clean and disinfect water distribution piping as follows:

1. Purge all new water distribution piping systems and parts of existing systems that have been altered, extended, or repaired prior to use.
2. Use the purging and disinfecting procedure proscribed by the authority having jurisdiction or, in case a method is not prescribed by that authority, the procedure described in either AWWA C651, or AWWA C652, or as described below:

    a. Flush the piping system with clean, potable water until dirty water does not appear at the points of outlet.

b. Fill the system or part thereof with a water/chlorine solution containing at least 50 parts per million of chlorine. Isolate (valve off) the system or part thereof and allow to stand for 24 hours.
c. Drain the system or part thereof of the previous solution and refill with a water/chlorine solution containing at least 200 parts per million of chlorine and isolate and allow to stand for 3 hours.
d. Following the allowed standing time, flush the system with clean, potable water until chlorine residual is lowered to incoming city water level.
e. Submit water samples in sterile bottles to the authority having jurisdiction. Repeat the procedure if the biological examination made by the authority shows evidence of contamination.

3. Reports: Prepare disinfection reports signed by the authority having jurisdiction and turn over to the Architect upon completion of the project.

3.16 COMMISSIONING

A. Fill the system. Check compression tanks to determine that they are not air bound and that the system is completely full of water.

B. Before operating the system, perform these steps:

1. Close drain valve, hydrants, and hose bibbs.
2. Open valves to full open position.
3. Remove and clean strainers.
4. Check pumps for proper direction of rotation. Correct improper wiring.
5. Lubricate pump motors and bearings.

END OF SECTION

SECTION 221111 - MECHANICALLY JOINED PLUMBING PIPING SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section only applies to Mechanically Joined Plumbing Piping Systems for joining piping for Plumbing applications as defined in Division Section 22 "Water Distribution Piping and Specialties".

B. The Division 22 contractor may provide mechanically joined couplings, fittings, valves and related components as an option in lieu of, in whole or in part, copper sweat, brazing, threaded or flanged piping methods.

C. Mechanically joined couplings, fittings, valves and related components specified in this section shall not be provided for natural gas piping in lieu of welded, threaded or flanged piping methods.

1.2 DEFINITIONS

A. Lead Free: Refers to the wetted surface of pipe, fittings and fixtures in potable water systems that have a weighted average lead content ≤0.25% per Safe Drinking Water Act as amended January 4th, 2011 Section 1417.

B. CWP: Cold working pressure in psi.

C. CTS: Copper tube size.

1.3 RELATED SECTIONS INCLUDE THE FOLLOWING:

A. Division 22 section "Basic Plumbing Piping Materials and Methods" for materials for dielectric waterway fittings and flange kits.

B. Division 22 Section "Water Distribution Piping and Specialties" for related sections.

1.4 SUBMITTALS

A. Product Data: Submit data for each type of coupling, fitting and special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure.

1. If an assembly of flexible couplings are used for seismic vibration, thermal expansion, or noise and vibration reduction, submit shop drawings indicating location of assembly, including anchors and guides. Include movement analysis of the assembly, and performance data of the assembly.

C. Maintenance Data: Include for each piping specialty and valve in Maintenance Manual specified in Division 01 and Division 22 Section "General Plumbing Requirements."

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Submit a schedule of dissimilar metal joints and adaptor flanges and flange kits. Include joint type material, connection method and proposed flange kits to isolate dissimilar metals. Include minimum and maximum torque requirements for flange connections to valves. Dielectric flange kits are specified in Division 22 section "Basic Plumbing Piping Materials and Methods".

F. Submit certification that valves and fittings for domestic water distribution comply with NSF 61 Annex G and / or NSF 372.

G. Submit certification that pipe, pipe fittings, pipe specialties, and valves and fittings are manufactured in plants located in the United States or certified that they comply with applicable ANSI, ASTM and MSS standards.

H. Submit contractor certificates indicating completion of installation training course from manufacturer of piping to be used.

1.5 QUALITY ASSURANCE

A. All grooved and press to connect components shall be of one manufacturer, be date and origin stamped for quality assurance and traceability.

B. Grooved mechanical piping shall conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B-39.1, ASME, UL/ULC, FM, IAPMO or ICC.

1. Components shall be capable of providing system rigidity to accommodate hanging and support in accordance with ANSI B31.1 and ANSI B31.9.

C. Grooved andpress to connect end product manufacturer shall be ISO certified.

D. Grooved couplings shall meet the requirements of ASTM F-1476.

E. Grooving tools shall be of an approved manufacturer by the grooved fittings manufacturer. Verify tolerances of and maintain grooving tool components for duration of grooving processes. Replace grooving tool components that are found out of tolerance with new as required.

F. Obtain training from the grooved and press to connect manufacturer for all workers that will be installing or handling the grooved or press to connect piping systems.

G. Comply with NSF 61 Annex G and / or NSF 372 for wetted surfaces of valves and fittings containing no more than 0.25% lead by weight for domestic water distribution.

H. Pipe, fittings, specialties, and valves shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ANSI, and MSS standards.

1.6 COORDINATION

A. Reference Division 22 Section "Water Distribution Piping and Specialties" for coordination.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Refer to manufacturer's current literature for comparable products and pressure ratings of couplings and standard fittings for various pipe sizes and pipe schedules. Products identified by model number are based on available size ranges from that manufacturer. Products offered by manufacturers with extended ranges are acceptable provided they meet the specified requirements.

B. Copper Grooved Copper Tubing System

1. Anvil International "Gruvlok".
2. Shurjoint Piping Products.
3. Victaulic Company of America.

C. Press to Connect Copper Tubing System

1. Apollo "Xpress"
2. GRINNELL Mechanical Products "G-Press"
3. NIBCO Inc., Press System.
4. Viega ProPress

2.2 COPPER GROOVED TUBING SYSTEM

A. Pipe:

1. 2 inch through 8 inch: CTS, ASTM B88 Type K or L, hard drawn.
2. Ends: Roll grooved only in accordance to manufacturer's current listed standards. Flaring of tube ends to IPS dimensions or to accommodate alternate sized couplings is not allowed.

B. General requirements for couplings, adapters, and standard fittings:

1. Full-flow type, compatible with ASTM B75 or B88 CTS grooved joints.
2. Flaring of tube ends to IPS dimensions or to accommodate alternate sized couplings is not allowed.

C. Couplings:

1. Material: Cast of ductile iron conforming to ASTM A536, Grade 65-45-12 or ASTM A395 Grade 65-45-15, coated with suitable enamel or epoxy.
2. Constructed of two-piece housing attached with bolts and nuts with pressure responsive elastomeric gasket, with pressure rating of 300 PSI at 180F. Provide washers where required by the manufacturer.
3. Rigid Type:

    a. Anvil International Gruvlok Series # 6402.
    b. Shurjoint Piping Products Styles #305, #306, and #307.
    c. Victaulic Style # 607.

4. Bolts, nuts, and washers:

a. Track-head bolts of heat treated carbon or manganese steel conforming to ASTM A183 or A449 with a minimum tensile strength of 110,000 psi.
b. Heavy-duty hexagonal nuts conforming to ASTM A563, Grade B.
c. Plated carbon steel flat washers conforming to ASTM F436.
d. Zinc-electroplated conforming to ASTM B633.
e. Type 304 or 316 stainless steel bolts and nuts conforming to ASTM A193, Grade B8/B8M, Class 2 or ASTM F593 and F594, Group 2, Condition CW.
f. Type 304 or 316 stainless steel washers.

D. Flange Adapters:

1. For connection to ANSI class components according to ANSI B16.1 (steel) or ANSI B16.24 (copper).
2. Material: Cast of ductile iron conforming to ASTM A536, Grade 65-45-12 or ASTM A395 Grade 65-45-15, coated with suitable enamel or epoxy.
3. 2 inch-6 inch (ANSI class 125/150):

a. Anvil International Gruvlok Series # 6084.
b. Shurjoint Piping Products Styles # C341.
c. Victaulic Style # 641.

E. Fittings:

1. Materials:

a. Wrought copper conforming to ASTM B75 alloy C12200 or ASTM B152 alloy C1100.
b. Lead free bronze sand cast conforming to ASTM B584 alloy UNS C89836.

F. Gaskets:

1. EPDM Gaskets:

a. Grade "E", "EHP" or "EHT" EPDM compound (green or red/green color coded, respectively) conforming to ASTM D2000 designation 2CA615A25B24F17Z.
b. Temperature operating range: -30 degrees F to +230 degrees F.
c. Style suitable for the application.

2. Fluoroelastomer Gaskets

a. Fluoroelastomer compound specifically formulated for compatibility with potable water systems resistant to chlorine and chloramine disinfectants (red and blue stripe color code).
b. Temperature operating range: 0 degrees F to +180 degrees F.
c. Style suitable for the application.

G. Valves:

1. Provide valves as specified in Division 22 section "General Duty Valves for Plumbing Piping."

2. 2 Inch through 6 Inch Butterfly Valve:

a. 300 psig CWP, CTS grooved ends, MSS SP-68, suitable for bidirectional and dead-end service at full rated pressure. Conform to Class IV leakage requirements per FCI/ANSI 70-2.
b. Body: Lead free, cast brass to UNS C87850, C90500, or cast bronze per ASTM B584.
c. Disc: Aluminum bronze disc or elastomer encapsulated ductile iron disc per ASTM A536 Grade 65-45-12.
d. Stem: Stainless steel.
e. Seat: Pressure responsive and of a grade suitable for the intended service.
f. Operator: Lever operators (10 position minimum) with locks and stops. Provide chain wheel for valves installed 72 inches or higher above finished floor elevation in mechanical rooms. Extend chains to an elevation of 5'-0" above finished floor elevation.
a. Anvil International Gruvlok Series # 6700]
g. Shurjoint Piping Products Style # SJ-C300
h. Anvil International Gruvlok Series #B6700Victaulic # 608N

H. Adapters – Grooved X Plain Copper

1. Wrought copper conforming to ASTM B75 alloy C12200 or ASTM B152 alloy C1100. CTS grooved end x plain end for press or sweat connection.

a. Anvil International Gruvlok Series #652
b. Shurjoint #C52

2.3 PRESS TO CONNECT COPPER TUBING SYSTEM

A. Copper Tube:

1. CTS ½inch through 4inch: ASTM B-88 Type K or L.

B. General requirements for couplings, adapters, and standard fittings:

1. Acceptable body materials:

a. Wrought copper conforming to ASTM B75 alloy C12200 or ASTM B152 alloy C1100.
b. Cast copper conforming to ASTM B584 alloy C87600 or C84400.

2. Coupling and fitting housings with soldered ends shall conform to ASME B16.18 and B16.22.
3. Coupling and fitting housings with flared ends shall conform to ASME B16.26.
4. Coupling and fitting housings with threaded ends shall conform to ASME B1.20.1.
5. Coupling and fitting housings for press ends shall have self-contained O-ring seals in the coupling/fitting ends.
6. Rated for 200 psi CWP up to 250 degrees F maximum.

C. O-Ring Seals: EPDM compound conforming to ASME B16.51, style suitable for the application.

D. Flange Adapters:

1. For connection to ANSI class components according to ANSI B16.1 (steel) or ANSI B16.24 (copper).
2. 2-1/2 inch through 4 inch (ANSI class 125/150):

a. Steel flange with NSF 14 compliant fused epoxy coating, copper or brass press to connect joint with copper face ring and plastic or rubber dielectric isolating ring separating the flange from the press to connect joint.

3. Rated for 200 psi CWP up to 250 degrees F maximum.

E. Valves:

1. Provide 2 inch and smaller press to connect valves listed in this section or lead free cast bronze valves 2 inch and smaller listed in Division 22 section "Water Distribution Piping and Specialties" may be used with sweat connections or sweat X press adapters.
2. Ball Valve:

a. Rated for 200 psi CWP up to 250 degrees F maximum, conforming to MSS SP-110.
b. Body and trim: Lead free cast bronze conforming to ASTM B62 or B584.
c. Ends: Female press to connect ends of copper material.
d. Ball: Full port, chrome-plated brass ball.
e. Stem: Blow-out proof, of material silicon bronze conforming to ASTM B371 or ASTM B99, or stainless steel.
f. Seat: PTFE or TFE, suitable for intended service.
g. Operator: Lever handle with non-thermal conductive material for insulated piping. Provide with 2 inch extended sleeve to allow valve operation without disturbing the insulation and with memory stop for throttling, metering or balancing service.

1) Apollo # 77WLF
2) NIBCO # PC-585-LF
3) Milwaukee # UPBA-450-12

3. Check Valves (Y pattern, swing type or in-line)

a. Rated for 200 psig CWP up to 250 degrees F maximum, conforming to MSS SP-80.
b. Body and trim: Cast bronze conforming to ASTM B62.
c. Disc: PTFE renewable seat and disc.
d. Ends: Female press to connect ends of copper or brass material.
e. 2 inch and smaller:

1) Apollo # 163T-PRLF
2) Hammond # UP904 P2
3) NIBCO # PF-413-Y-LF
4) Milwaukee # UP509 P2

4. Check Valves (lift type, in-line)

a. Rated for 250 psig CWP up to 250 degrees F maximum, conforming to MSS SP-80.
b. Body: Cast bronze conforming to ASTM B584.
c. Spring: 316 stainless steel.
d. Ends: Female press to connect ends of copper or brass material.
e. 2 inch and smaller:

1) Apollo # 61LF
2) Milwaukee # UP548T P2

5. Butterfly Valves – 2-1/2 inch and Larger

a. MSS SP-67; 200-psi CWP; lug-type body constructed of ductile iron conforming to ASTM A 126, Class B or ductile iron conforming to ASTM A 536. Provide valves

with field replaceable EPDM sleeve/seat, CF8M (316) stainless steel disc, 416 stainless steel stem, and EPDM O-ring stem seals. Provide lever operators, (10 position minimum), with lock and stops with locks. Drill and tap valves on dead-end service or requiring additional body strength. Valves must be rated for dead end service at 150 psi with no downstream flange required. Provide with factory installed press to connect flange adapters, as described herein, with bolts, nuts and washers.

1) NIBCO # PFD2022
2) Viega # 2873.81

F. Strainers:

1. Provide 2 inch and smaller press to connect strainers listed in this section or lead free cast bronze strainers 2 inch and smaller listed in Division 22 section "Basic Piping Materials and Methods" may be used with sweat connections or sweat X press adapters.
2. Strainers (Y pattern)

a. Rated for 250 psig CWP up to 250 degrees F maximum.
b. Body: Cast bronze conforming to ASTM B584.
c. Screen: Stainless steel mesh with 0.062" perforations.
d. Ends: Female press to connect ends of copper or brass material.
e. 2 inch and smaller:

1) Apollo # 59LF

PART 3 - EXECUTION

3.1 PIPING INSTALLATIONS

A. Install pipe, fittings, valves and specialties in accordance with manufacturer's installation instructions.

B. Water distribution piping installations shall be installed subject to Division 22 Section "Water Distribution Systems and Specialties" in addition to those requirements specified in this Section.

C. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

3.2 PIPE APPLICATIONS ABOVE GRADE

A. Water piping in sizes 2-1/2 to 8 inches shall be Type L drawn copper tube with roll-grooved ends and copper tube dimensioned mechanical couplings and fittings or water piping sizes 2-1/2 inch to 4 inch shall be Type L drawn copper tube with plain ends and copper tube dimensioned press to connect fittings.

B. Water piping in sizes 2inches and smaller shall be Type L drawn copper tube with plain ends and copper tube dimensioned press to connect copper couplings and fittings.

3.3 HANGERS AND SUPPORTS

A. Support of piping must account for expansion and contraction, vibration, and the dead load of the piping and its contents.

B. General: Hanger supports, and anchors devices are specified in Division 22 Section "Hangers and Supports for Plumbing Piping." Reference Division 22 Section "Water Distribution Systems and Specialties" for pipe spacing limitations.

3.4 PIPE JOINT CONSTRUCTION

A. Copper Grooved tubing System

1. Pipe ends shall be clean and free from oils, indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.
2. Roll and cut groove ends in accordance to manufacturer's current listed standards. Use rolls sets designed and intended for use on the appropriate pipe material when grooving pipe.
3. Flaring of CTS tube ends to IPS dimensions or to accommodate alternate sized couplings is not allowed.
4. Verify the gasket style and elastomeric material (grade) is suitable for the intended service as specified and in combination with any system chemical additive.
5. Reference latest published manufacturer's product data for additional pressure ratings and application information.
6. Reference latest published manufacturer's field installation instructions or other included installation instruction prior to attempting assembly.
7. Ream, deburr and clean tube ends and verify they are free from indentations, projections and roll marks in the area from tube end to groove for proper gasket sealing.
8. All grooved components (couplings, fittings, valves, gaskets, bolts and nuts) shall be of one manufacturer. All grooving tools shall be of one manufacturer, though not necessarily the same as the grooved component manufacturer.
9. Install gaskets with lubricant suitable for all piping services. Lubricant shall be by one manufacturer.

B. Press to connect Copper Tubing System

1. Ream, deburr and clean tube ends and verify they are free from indentations, projections, burrs and foreign matter.
2. Install permanent inspection mark on tube.
3. Clean tube and fittings of all dirt and oil. Verify O-ring is in place and free of oil, grease or dirt.
4. Push copper tube into fittings with twisting action to all the way to the fitting stop or shoulder.
5. Mark tube with permanent marker to indicate proper tube insertion depth.
6. Verify press tool has correct size jaw set for tube size used.
7. Complete one tool cycle with empty jaw to calibrate tool for each time new jaw is inserted into tool.
8. Squeeze jaw arms to open tool jaws and place jaws around the contour of the fitting. Verify tool is perpendicular to the fitting and depress tool switch.
9. Squeeze jaw open to remove the tool and observe witness mark.

10. Verify crimped fitting connection for misalignment of the copper tube, misalignment of the tool or improper insertion of the tube. If any of these conditions are found cut out the joint and provide a new joint.
11. Maintain minimum distance between joints per the manufacturer's published installation instructions.

C. Dielectric Isolation Requirements for Copper Grooved Connections: Provide dielectric grooved waterway fittings or couplings at grooved galvanized steel, stainless steel or ductile iron to grooved copper joints. Dielectric waterway fittings are specified in Section "Basic Piping Materials and Methods".

D. Dielectric Isolation Requirements for Press to Connect Adapter Flange Connections: Provide dielectric flanges or flange kits for the following joint types:

1. Adapter Flanges to Iron, Ductile Iron or Steel Body Valves and Fittings (Except Butterfly Valves with EPDM Sleeve/Seats): Provide full face gaskets between flanges and adapter flanges. At each bolt provide, steel washers, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves on valve and adapter flanges.
2. Full face gaskets, thermoplastic washers and bolt isolation sleeves or thermoplastic combination washers and bolt sleeves are specified in Section "Basic Piping Materials and Methods".

E. Flange Adapters:

1. Install flange adapter washers when flange adapters are used against the following surfaces:

   a. Rubber.
   b. Adapting to ANSI/AWWA cast flanges.
   c. Rubber faced lug valves.
   d. Serrated flanged surfaces.

2. Do not install flange adapters for applications that incorporate tie rods for anchoring or on standard grooved-end fittings within 90 degrees of each other.

3.5 VALVE APPLICATIONS

A. Reference Division 22 Section "Water Distribution Piping and Specialties" for valve applications.

3.6 EQUIPMENT CONNECTIONS

A. Press to connect joints shall not be provided for equipment connections. Provide flanges, unions, or waterway fittings. Flanges, unions, di-electric unions and waterway fittings are specified in Division 22 specification section "Basic Piping Materials and Methods"

3.7 STRAINERS

A. Provide strainers as specified in part 2 of this specification section or Division 22 specification section "Basic Piping Materials and Methods".

1. Provide manufacturer strainer with press to connect ends for 2 inches and smaller.

2. Provide copper press to connect X screwed NPT adapters for 2 inches and smaller.
3. Provide press to connect adapter flanges for 2-1/2 inches to 4 inches.

3.8 WATER DISTRIBUTION SPECIALTIES INSTALLATION

A. Reference Division 22 Section "Water Distribution Systems and Specialties" for water distribution specialties and installation requirements.

3.9 FIELD QUALITY CONTROL

A. The following procedures are paraphrased from the ASME B-31.9, code for pressure piping, building services piping.

B. Installing contractor shall schedule training session with the grooved or press to connect manufacturer for all workers that will be installing or handling the grooved or press to connect piping systems. Submit certification letter along with list of attendees to engineer of record within 30-days of mobilization. Include copy of certification letter with closeout documents.

C. Grooved and Press to connect fitting manufacturer shall provide certification training to contractor without cost and without additional cost to Owner.

D. Provide testing procedures as defined in Division 22 Section "Water Distribution Systems and Specialties" and as specified in grooved mechanical piping manufacturer's installation instructions.

E. Installing contractor shall visually inspect couplings and repair or replace any misaligned couplings and couplings with gaps prior to calling for inspection as defined in Division 22 Section "General Plumbing Requirements."

F. Grooved and Press to connect fitting manufacturer's representative shall make periodic visits to the jobsite during construction to ensure the installing contractor is following the latest published manufacturer's field installation instructions and best practice procedures provided during the training session.

3.10 STARTUP

A. Refer to Division 22 Section "Water Distribution Piping and Specialties" for startup procedures.

END OF SECTION

SECTION 221113 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 3900 Water Mains of the City of Lee’s Summit, Missouri Standard Specifications, Current Edition.

1.2 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for water service and fire-service mains. All private work shall be in accordance with Section 3900 Water Mains of the City of Lee’s Summit, Missouri Standard Specifications, Current Edition.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

1.4 QUALITY ASSURANCE

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

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

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

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

E. NSF Compliance:
   1. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.5 DELIVERY, STORAGE, AND HANDLING

A. All delivery, storage, and handling of materials shall comply with manufacturer's recommendations. In general:

B. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

C. During Storage: Use precautions for valves, including fire hydrants, according to the following:
1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

D. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

E. 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.

F. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

G. Protect flanges, fittings, and specialties from moisture and dirt.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service:
1. Coordinate with City of Lee's Summit Water Utilities 48 hours in advance or Lee's Summit School District as applicable

PART 2 - PRODUCTS

2.1 CLASS 50 DUCTILE IRON PIPE (DIP) AND FITTINGS FOR FIRE PROTECTION LINE AND DOMESTIC SERVICE LINES (6" AND LARGER). CLASS 51 DUCTILE IRON PIPE (DIP) FOR 3 AND 4" FIRE PROTECTION AND DOMESTIC SERVICE LINES.

A. Comply with Section 3901 B & C of the City of Lee's Summit, Missouri Standard Specifications.

2.2 PRESSURE CLASS 235 POLYVINYL CHLORIDE PIPE (PVC C900) AND FITTINGS FOR FIRE PROTECTION LINE AND DOMESTIC SERVICE LINES (4" AND LARGER).

A. Comply with Section 3901 B & D of the City of Lee's Summit, Missouri Standard Specifications.

2.3 SOFT TYPE “K” COPPER CONFORMING TO ASTM B88 FOR DOMESTIC SERVICE LINES (2” AND SMALLER).

2.4 VALVES

A. Comply with Section 3901 M of the City of Lee’s Summit, Missouri Standard Specifications

2.5 VALVE ACCESSORIES AND SPECIALTIES

A. Tapping Valves:
1. Comply with Section 3901 N of the City of Lee’s Summit, Missouri Standard Specifications

B. Valve Boxes:
1. Comply with Section 3901 O of the City of Lee’s Summit, Missouri Standard Specifications

C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.6 CASING PIPE

A. Comply with Section 3901 s of the City of Lee’s Summit, Missouri Standard Specifications

2.7 FIRE HYDRANTS

A. Refer to Section 3901 Q of the City of Lee’s Summit, Missouri Standard Specifications. All fire hydrant branches shall be restrained using approved restraining devices. Hydrants shall be installed so that the centerline of the outlet nozzle is between eighteen inches above finished grade, and so that there is a minimum clear area of 5' in each direction to allow operation of the hydrant. All fire hydrants are to be set with the base 2" to 6” above the top of curb or grade. Fire hydrants shall be painted in accordance with Section 3901 Q.9.

2.8 BACKFLOW PREVENTION DEVICES

A. Refer to Section 3901 P of the City of Lee’s Summit, Missouri Standard Specifications.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

E. Underground Fire Protection Line Piping to building shall be DIP in accordance with, Section 3901 C & B of the City of Lee's Summit, Missouri Standard Specification, Subject to restrictions based on the City's currently adopted Fire Code.

3.3 VALVE APPLICATIONS

A. General Application: All joints shall be restrained. Use mechanical-joint-end valves for 3" and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for 2" and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, valves shall comply with Section 3901 of the City of Lee's Summit Standard Specifications.

3.4 PIPING INSTALLATION

1. Comply with Section 3902 B of the City of Lee's Summit, Missouri Standard Specifications.

B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

C. Bury piping with depth of cover over top at least 42 inches.

D. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

E. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

F. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

3.5 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
   1. Concrete thrust blocks.
   2. Refer to Plans and Section 3902 B.6 of the City of Lee's Summit, Missouri Standard Specifications

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches.

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

3.6 VALVE, FITTINGS AND HYDRANT INSTALLATION

A. Comply with Section 3902 B.9 of the City of Lee's Summit, Missouri Standard Specifications.

3.7 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to the City of Lee's Summit Water Utility Department's written instructions (if applicable) and Section 3902 B.5 of the City of Lee's Summit, Missouri Standard Specifications.

3.8 ROUGHING-IN FOR BACK FLOW PREVENTERS AND WATER METERS

A. Rough-in piping and specialties for back flow preventers and water meter installation according to utility company's written instructions.

3.9 CONNECTIONS AND ABANDONMENT

A. Connect water-distribution piping to existing water main. Reference to Section 3902 B.11 of the City of Lee's summit, Missouri Standard Specifications.

B. Connect water-distribution piping to interior domestic water and fire-suppression piping as applicable.

C. Abandonment of water-distribution piping shall be completed in accordance with Section 3902 B.12 of the City of Lee's Summit, Missouri Standard Specifications. Water Utilities within the 5' of the proposed building addition or with conflict of other utilities or improvements shall be removed.

3.10 CONCRETE VAULT AND METER PIT INSTALLATION

A. Install precast concrete vaults according to Lee's Summit requirements. Set lids flush with grade if located in sidewalks, 1" above grade if located in lawn areas.

3.11 FIRE HYDRANT INSTALLATION

A. Comply with Section 3902 B.9d of the City of Lee's Summit, Missouri Standard Specifications.

3.12 FIELD QUALITY CONTROL

A. Hydrostatic pressure and leakage testing shall be performed by the contractor per Section 3902.D of the City of Lee's Summit, Missouri Standard Specifications.

3.13 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Section 330500 "Common Work Results for Utilities" for identifying devices.

3.14 CLEANING

A. Clean and disinfect water-distribution piping in accordance with to KC Metropolitan Chapter of APWA Specifications, Section 2903.9 A.

END OF SECTION 221113

SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes the following types of plumbing pumps:

1. Cartridge type inline circulators
2. Inline circulator pumps

B. Related Sections: The following sections contain requirements that relate to this Section:
1. Division 22 Section "Coordination" for basic requirements for electrical components that are an integral part of packaged system components.
2. Division 22 Section, "Basic Piping Materials and Methods" for rubber flexible connectors.
3. Division 26 Section "Common Work Results for Electrical" required electrical devices.
4. Division 26 Sections "Enclosed Switches and Circuit Breakers" for field-installed disconnects.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product data including standard performance curves, weights (shipping, installed, and operating), furnished specialties, and accessories, plus installation and start-up instructions.
2. Shop drawings showing layout and connections for plumbing pumps. Include setting drawings with templates, and directions for installation of foundation bolts, anchor bolts, and other anchorages.
3. Wiring diagrams detailing wiring for power, signal, and control systems; differentiating between manufacturer-installed wiring and field-installed wiring.

4. Maintenance data for plumbing pumps, for inclusion in Operating and Maintenance Manuals specified in Division 1 and Division 22 Section "General Plumbing Requirements."

1.3 QUALITY ASSURANCE

A. Hydraulic Institute Compliance: Design, manufacture, and install plumbing pumps in accordance with "Hydraulic Institute Standards."

B. National Electrical Code Compliance: Components shall comply with NFPA 70 "National Electrical Code."

C. UL Compliance: Plumbing pumps shall be listed and labeled by UL and comply UL Standard 778 "Motor Operated Water Pumps."

D. UL Compliance: Control panels shall be listed and labeled by UL and comply with Standard 508A "Control Panels".

E. NEMA Compliance: Electric motors and components shall be listed and labeled NEMA.

F. Single-Source Responsibility: Obtain plumbing pumps of the same type from a single manufacturer.

G. Design Criteria: The Drawings indicate sizes, profiles, connections, and dimensional requirements of plumbing pumps and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided that deviations in dimensions and profiles do not change the design concept or intended performance as judged by the Architect. The burden of proof for equality of plumbing pumps is on the proposer.

H. Valves, pumps and fittings shall be manufactured in plants located in the United States or certified that they comply with applicable ANSI, ASTM and MSS standards.

1.4 SPARE PARTS

A. Furnish spare parts described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal for each pump.

1.5 WARRANTY

A. Warranty on Pumps: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, pumps with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement includes both parts and labor for removal and reinstallation.

1. Warranty Period: One year from date of substantial completion.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the following:

1. Cartridge Type Inline Circulators:

a. Armstrong Pumps, Inc.
b. Bell & Gossett, ITT.
c. Grundfos Pumps, Corp.
d. Taco, Inc.

2. Inline Circulator Pumps:

a. Armstrong Pumps, Inc.
b. Bell & Gossett, ITT.
c. Grundfos Pumps, Corp.

d. Taco, Inc.

3. Aquastats:

a. Dayton
b. Honeywell
c. Penn
d. White-Rodgers

2.2 PUMPS, GENERAL

A. Pumps and circulators: factory assembled and factory tested.

B. Preparation for shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anticorrosion compound. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

C. Motors: Conform to NEMA standards; single, multiple, or variable speed with type of enclosure and electrical characteristics as indicated; have built-in thermal-overload protection and grease-lubricated ball bearings. Select motors that are nonoverloading within the full range of the pump performance curve.

D. Apply factory finish paint to assembled, tested units prior to shipping.

2.3 CARTRIDGE TYPE CIRCULATOR PUMPS

A. General Description: Leakproof, inline, seamless, volute-type pump. Pump and motor shall be assembled on a common shaft in a single hermetically sealed unit, without stuffing boxes or mechanical seals. Accomplish sleeve bearings lubrication by circulating pumped liquid through the motor section. Isolate motor section from the motor stator windings with a thin corrosion-resistant, nonmagnetic, alloy liner. Pumps shall be rated for 125 psig working pressure and 225 deg F continuous water temperature.

B. Casings: Cast lead free bronze, with stainless steel liner and static O-ring seal to separate motor section from motor stator, and with union piping connections.

C. Impeller: Overhung, single-suction, closed or open nonmetallic impeller.

D. Pump Shaft and Sleeve: Stainless steel shaft with carbon steel bearing sleeve.

E. Motors: 1750 RPM one piece sealed type.

2.4 INLINE CIRCULATOR PUMPS

A. General Description: Circulators shall be horizontal inline, centrifugal, separately coupled, single-stage, all-bronze, radially split case design, with mechanical seals, permanently lubricated ball bearings and rated for 125 psig working pressure and 225 deg F continuous water temperature.

B. Casings: Cast lead free bronze, with threaded companion flanges for piping connections smaller than 2-1/2 inches, and threaded gauge tappings at inlet and outlet connections.

C. Impeller: Statically and dynamically balanced, closed, overhung, single suction, fabricated from cast lead free bronze conforming to ASTM B 584, and keyed to shaft.

D. Pump Shaft and Sleeve: Steel shaft with oil-lubricated copper sleeve.

E. Mechanical Seals: Carbon steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.

F. Pump Bearings: Oil-lubricated, bronze journal and thrust bearings.

G. Motor Bearings: Oil-lubricated sleeve bearings.

H. Shaft Couplings: Flexible; capable of absorbing torsional vibration and shaft misalignment.

I. Motors: Resiliently mounted to the pump casing.

2.5 AQUASTATS:

A. Remote sensing bulb type, non-modulating, single pole double pole throw with surface mount sensing bulb and mounting bracket, adjustable direct reading scale for set point with adjustable differential.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps in accordance with manufacturer's installation instructions.

B. General: Comply with the manufacturer's written installation and alignment instructions.

C. Install pumps in locations and arrange to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

D. Support pumps and piping separately so that the weight of the piping system does not rest on the pump.

E. Suspend inline pumps with all thread hanger rod and vibration isolation hangers of sufficient size to support the weight of the pump independent from the piping system.

3.2 EXAMINATION

A. Examine areas, equipment foundations, and conditions with Installer present, for compliance with requirements for installation and other conditions affecting performance of plumbing pumps. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine rough-in for plumbing piping systems to verify actual locations of piping connections prior to installation.

3.3 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundations, after grout has been set and foundations bolts have been tightened, and after piping connections have been made.

1. Adjust alignment of pump and motor shafts for angular and parallel alignment by one of the two methods specified in the Hydraulic Institute "Centrifugal Pumps - Instructions for Installation, Operation and Maintenance."

B. After alignment is correct, tighten the foundation bolts evenly but not too firmly. Fill the base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

1. Alignment tolerances shall meet manufacturers recommendations.

3.4 CONNECTIONS

A. General: Install valves that are same size as the piping connecting the pump.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

C. Install a nonslam check valve and shutoff valve on the discharge side of pumps.

D. Install a ball valve and strainer on the suction side of inline pumps.

E. Install surface mounted aquastat on bare metal pipe, fastened securely to pipe upstream of circulator pump when indicated on the drawings.

F. Interlock aquastat and or timer with hot water recirculation pump motor. Electrical wiring and connections are specified in Division 26 section "Common Work Results for Electrical".

G. Electrical wiring and connections are specified in Division 26 section "Common Work Results for Electrical".

H. Alarm wiring and alarm interlock with the building automation system are specified in Division 23 Section "Direct-Digital Control for HVAC".

3.5 FIELD QUALITY CONTROL

A. Check suction lines connections for tightness to avoid drawing air into the pump.

3.6 STARTUP

A. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

1. Lubricate oil-lubricated bearings.

2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.
3. Disconnect coupling and check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.

B. Starting procedure for pumps with shutoff power not exceeding the safe motor power:

1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.
2. Open the valve in the cooling water supply to the bearings where applicable.
3. Open the sealing liquid supply valve if the pump is so fitted.
4. Open the warm-up valve of a pump handling hot liquids if the pump is not normally kept at operating temperature.
5. Open the recirculating line valve if the pump should not be operated against dead shutoff.
6. Start motor.
7. Open the discharge valve slowly.
8. Observe the leakage from the stuffing boxes and adjust the sealing liquid valve for proper flow to ensure the lubrication of the packing. Do not tighten the gland immediately, but let the packing run in before reducing the leakage through the stuffing boxes.
9. Check the general mechanical operation of the pump and motor.
10. Close the recirculating line valve once there is sufficient flow through the pump to prevent overheating.

C. If the pump is to be started against a closed check valve with the discharge gate valve open, the steps are the same except that the discharge gate valve is opened some time before the motor is started.

END OF SECTION

SECTION 221300 - SANITARY DRAINAGE AND VENT PIPING AND SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes building sanitary drainage and vent piping systems, including drains and drainage specialties.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "General Plumbing Requirements," for trenching and backfilling materials and methods for underground piping installations.
2. Division 33 Section "Sanitary Sewage Systems," for sanitary drainage piping beginning from 5'-0" outside the building.
3. Division 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
4. Division 12 Section "Laboratory Casework and Fixtures," for laboratory drains and trim furnished with the casework.
5. Division 22 Section "Plumbing Identification," for labeling and identification of drainage and vent piping.
6. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations, wall and floor penetrations and equipment pads
7. Division 22 Section "Basic Piping Material and Methods," for materials and methods for mechanical sleeve seals.
8. Division 22 Section "Hangers and Supports for Plumbing Piping," for materials and methods for hanging and supporting drainage and vent piping.
9. Division 22 Section "Plumbing Insulation," for materials and methods for insulating drainage piping.
10. Division 22 Section "Water Distribution Piping and Specialties," for material and methods for trap primers and trap primer inlet piping.
11. Division 22 Section "221328 Condensate Pumps for HVAC Equipment," for material and methods for condensate pumps.

1.2 DEFINITIONS

A. Sanitary Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste and other drainage pipes inside the walls of the building and conveys it to the building sewer.

B. Sanitary Building Sewer: That part of the drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.

C. Drainage System: Includes all the piping within a public or private premises which conveys sewage or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.

D. Vent System: A pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specifications Sections.

B. Product data for the following products:

1. Drainage piping
2. Drainage piping specialties
3. Floor drains

C. Test reports specified in Part 3 of this Section.

1.4 QUALITY ASSURANCE

A. Comply with the installation requirements for CPVC pipe and CPVC CTS tube per the Lubrizol "FlowGuard Gold and CORZAN Design and Installation Manual" and the installed manufacturer's installation manual.

B. Regulatory Requirements: Comply with the provisions of the following codes:
1. 199_2018 International Plumbing Code

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

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

1. Drainage Piping Specialties, including cleanouts and floor drains:

a. Josam Mfg. Co.
b. Sioux Chief Manufacturing Co. Inc.
c. Jay R. Smith Mfg. Co.
d. Tyler Pipe/Wade Div.; Subs. of Tyler Corp.
e. Watts Industries, Inc.
f. Zurn Industries, Inc.; Hydromechanics Div.
g. Mifab Manufacturing Co.

2. Heavy Duty Hubless Couplings

a. Anaco Husky HD-2000
b. Clamp-All 80in. lb.
c. Ideal Tridon "HD"
d. ProFlo "HD"
e. Mission Rubber Company, "Heavy Weight"

3. Cast Iron Soil Pipe and Fittings

a. AB & I Foundry
b. Charlotte Pipe and Foundry Company
c. Tyler Pipe / Soil Pipe Division

4. Shielded Transition Couplings

    a. FERNCO, "Proflex 3000 Series"
    b. Mission Rubber Company, "Band Seal Specialty Couplings"

5. Underground Shielded Adapter Couplings

    a. FERNCO, "1056 Series with SR73 Shear Ring"
    b. Mission Rubber Company, "MR56 Series"

6. Trap Seals

    a. Green Drain, Inc.
    b. Jay R. Smith Mfg. Co.
    c. Mifab Manufacturing, Inc.
    d. Proset Systems "Trap Guard"
    e. Sure Seal, Inc.
    f. Zurn Industries, Inc.; Hydromechanics Div.

7. Hubless Couplings:

    a. Anaco
    b. Ideal Tridon
    c. Mission Rubber Company
    d. ProFlo "PFNH"
    e. Tyler Pipe / Soil Pipe Division

2.2 ABOVE GROUND DRAINAGE AND VENT PIPE AND FITTINGS

A. Cast-Iron Soil Pipe: CISPI 301 and ASTM A888, no-hub pipe and fittings and bearing the trademark of CISPI and NSF.

    1. Couplings and compression gaskets, NSF certified: ASTM C564 and CISPI 310.

    2. Heavy duty couplings and compression gaskets: ASTM C1540 and meeting FM 1680.

B. Copper Tube: ASTM B306, Type DWV, hard drawn for pipe, and cast copper alloy solder joint drainage fittings (DWV) meeting ASME / ANSI B16.23.

    1. Solder Filler Materials: ASTM B32, 95-5 tin-antimony solder.

C. Copper Tube: ASTM B88, Type M, hard drawn for pipe and wrought copper fittings with soldered joints.

    1. Solder Filler Materials: ASTM B32, 95-5 tin-antimony solder.

D. PVC DWV Pipe and Fittings (as contractor's option used in wall only): Schedule 40 pipe meeting ASTM D1785 and ASTM D2665 with "solid wall" PVC meeting ASTM D1784 with cell class 12454-B.

    1. Fittings: DWV pattern meeting ASTM D2665 with solvent cement socket joints.
    2. Solvent: ASTM D2564.

E. Steel Pipe: ASTM A53, Type E or S, schedule 40, Grade B, galvanized, threaded ends.

1. Galvanized Malleable Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ASME B1.20.1.

F. Shielded Transition Couplings: ASTM C1460 with neoprene adapter gasket with stainless steel Shield and hose clamps.

2.3 UNDERGROUND BUILDING DRAIN AND VENT PIPE AND FITTINGS

A. PVC DWV Pipe and Fittings: Schedule 40 pipe meeting ASTM D1785 and ASTM D2665 with "solid wall" PVC meeting ASTM D1784 with cell class 12454-B.

1. Fittings: DWV pattern meeting ASTM D2665 with solvent cement socket joints.
2. Solvent: ASTM D2564.

B. Underground Shielded Adapter Couplings: ASTM C1173 with neoprene adapter gasket with stainless steel shield and stainless steel hose clamps.

2.4 DRAINAGE PIPING SPECIALTIES

A. Cleanout Plugs: Cast bronze or brass, threads complying with ANSI B2.1, countersunk head.

B. Floor Cleanouts: Cast iron body and frame, cleanout plug, adjustable nickel-bronze top, exposed flush type, standard non-slip scored or abrasive finish.

C. Wall Cleanouts: As specified on the drawings.

D. Floor Drains: As specified on the drawings.

E. Trap seals: Provide trap seals meeting either description below:

1. Smooth, soft, flexible, elastomeric PVC material molded into shape of duck's bill, open on top with curl closure at bottom. The flow of wastewater allows duck's bill to open and adequately discharge to floor drain through its interior. The duck's bill closes and returns to original molded shape after wastewater discharge is complete. Or, smooth, soft, flexible, elastomeric PVC material with a flapper closure. The flow of wastewater allows flapper to open and adequately discharge to floor drain through its interior. The flapper closes and returns to original molded shape after wastewater discharge is complete.
2. Smooth, soft, flexible, elastomeric PVC material with a flapper closure. The flow of wastewater allows flapper to open and adequately discharge to floor drain through its opening. The flapper closes and returns to original position after wastewater discharge is complete.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install pipe and specialties in accordance with manufacturer's installation instructions.

3.2 PREPARATION FOUNDATION FOR UNDERGROUND SANITARY BUILDING DRAINS

A. Pipe Beds:

1. PVC and ABS Pipe: Support pipe in trench with sand bags level and true to prevent sand, gravel or debris from interfering with the solvent cement process. After pressure testing is complete, gradually install bedding to maintain continuous pipe slope and prevent pipe deflection and then install subbase. Refer to Section "General Plumbing Requirements" for bedding and subbase materials, excavation, trenching, backfill and compaction requirements and refer to ASTM D2321 "Underground Installation of Thermoplastic Pipe for Sewers and Gravity-flow Applications" for additional requirements.

3.3 PIPE APPLICATIONS - ABOVE GROUND, WITHIN BUILDING

A. Install hubless, cast-iron soil pipe and fittings for 15" and smaller soil, waste, and vent pipe.

B. Install Type DWV copper tube with cast copper alloy solder joint drainage fittings (DWV) fittings, copper sweat X screwed with solder joints, for waste connections from urinals, lavatories, sinks, water coolers to cast iron drainage piping.

C. Condensate drain piping and pumped condensate drain piping inside the building: Provide ¾" minimum size or as indicated on the drawings. Slope gravity drainage condensate piping from mechanical equipment at 1/8" per foot minimum slope. Discharge to floor receptor with air gap. Condensate piping shall match equipment connection size with cleanout at trap. Provide condensate pump at each unit where proper slope cannot be maintained. Double tee cross fitting shall not be used with exception to vents.
1. Install Type M copper tube with wrought copper fittings with solder joints, 1" and smaller and install Type DWV copper tube with cast copper alloy solder joint drainage fittings (DWV) fittings for 1-1/4" and larger. Provide galvanic isolators as specified in Division 22 "Basic Piping Materials and Methods". Where condensate from multiple units is combined to a single drain, provide cleanout at the start of the pipe and as required for Above Grade Cleanouts in this section.

D. Condensate drain piping outside the building: Provide ¾" minimum size or as indicated on the drawings. Slope condensate piping at 1/8" per foot minimum slope to discharge point. Discharge to roof receptors or roof drains with air gap. Condensate piping shall match equipment connection size with cleanout at trap. Provide condensate pump at each unit where proper slope cannot be maintained. Double tee cross fitting shall not be used with exception to vents.
1. Install Type M copper tube with wrought copper fittings with solder joints, 1" and smaller, and install Type DWV copper tube with cast copper alloy solder joint drainage fittings (DWV) fittings for 1-1/4" and larger. Provide galvanic isolators as specified in Division 22 "Basic Piping Material and Methods".

3.4 PIPE APPLICATIONS - BELOW GROUND, WITHIN BUILDING

A. Install PVC Type DWV Plastic pipe and fittings for drainage and vent pipe for 24" and smaller.

3.5 PIPE AND TUBE JOINT CONSTRUCTION

A. Copper Tubing: Solder joints in accordance with the procedures specified in AWS "Soldering Manual."

B. Cast-Iron Soil Pipe: Make hubless joints in accordance with the Cast-Iron Soil Pipe & Fittings Handbook, Chapter IV. Install Couplings as followings:
   1. Install hubless couplings complying with CISPI 310 on and soil and waste piping 3" and smaller and all vent piping.
   2. Install heavy duty hubless couplings on soil or waste stacks, soil and waste piping connections to soil or waste stacks and all soil and waste piping 4" and larger.

C. PVC DWV Pipe: Joining and installation of PVC drainage pipe and fittings shall conform to ASTM D2665.

D. ABS to PVC Transition Joints: When joining ABS to PVC components (such as an ABS building drain to PVC sewer pipe) make joints using solvent cements conforming to ASTM D3138.

E. Cast Iron to PVC Above Grade: Join cast iron to PVC with shielded transition couplings.

F. Cast Iron to PVC Below Grade: Join cast iron to PVC with underground shielded adapter couplings.

3.6 INSTALLATION

A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing, slope, expansion, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and all branch connections.

C. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

D. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

E. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

F. Install horizontal piping as high as possible allowing for proper slope and coordination with other components. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

G. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and sealer. Refer to Division 22 Section " Basic Piping Material and Methods" for special sealers and materials.

H. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings and floors, maintain the fire rated integrity. Refer to Division 22 Section " Basic Piping Material and Methods" for special sealers and materials.

I. Foundation Penetrations: Where pipes pass through foundation walls above strip footings or under strip footings, protect pipes from building load with cast iron soil pipe sleeves two pipe sizes larger than the pipe. Sleeves installed under the strip footing shall be encased in concrete.

J. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of Non-Fire Rated Walls and Concrete Slab on Grade Penetrations: Provide sleeves and seal pipes that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 22 Section "Common Work Results for Plumbing" for special sealers and materials.

K. Make changes in direction for drainage and vent piping using appropriate 45 degree wyes, combination wye and eighth bend, or long sweep, quarter, sixth, eighth, or sixteenth bends. Sanitary tees or quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn pattern combination wye and eighth bends where two fixtures are installed back to back and have a common drain. Straight tees, elbows, and crosses may be used on vent lines. Double wyes or double wye combinations shall not be used in the horizontal. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper sized standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

L. Install underground building drains to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

M. Install drainage piping pitched down at a minimum slope of 1/4 inch per foot (2 percent) for piping 3 inch and smaller, and 1/8 inch per foot (1 percent) for piping 4 inch and larger. Install vent piping pitched to drain back by gravity to the sanitary drainage piping system.

N. Extend building drain to connect to service piping, of size and in location indicated for service entrance to building. Sewer service piping is specified in a separate section of Division 2.

3.7 HANGERS AND SUPPORTS

A. General: Hanger, support, insulation protection shields, and anchor components and installation procedures conforming to MSS SP-58 and SP-69 are specified in Division 22 Section "Hangers and Supports for Plumbing Piping". Conform to the table below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable clevis hangers, MSS SP-69 Type 1, for individual horizontal runs.
2. Riser clamps, MSS SP-69 Type 8, for individual vertical runs.
3. Insulation protection shields and high density insulation at each hanger for insulated pipe as specified in Division 22 Sections "Hangers and Supports for Plumbing Piping" and "Plumbing Insulation".

    a. Install high density insulation on insulated pipe.

4. Provide vinyl coated hangers and riser clamps for use with PVC pipe.

C. Install hangers at the following intervals and provide rods of diameter as listed below:

Nom. Pipe Size	Steel Pipe Max. Span	Copper Tube Max. Span.	Min. Rod Dia. - Inches Steel or	Min. Rod Dia. – Inches

In Inches	In Feet	In Feet	Cast Iron	Copper
Up to 3/4	7	5	3/8	3/8
1	7	6	3/8	3/8
1-1/4	7	7	3/8	3/8
1-1/2	9	8	3/8	3/8
2	10	8	3/8	3/8
2-1/2	11	9	1/2	3/8
3	12	10	1/2	1/2
3-1/2	13	11	1/2	1/2
4	14	12	5/8	1/2
5	16	13	5/8	1/2
6	17	14	3/4	5/8

1. Support all sizes of service weight horizontal cast iron piping every five feet, except up to ten feet where ten foot sections are installed. Support all sizes of hubless horizontal cast iron piping every other joint, unless over four feet, then support each joint. Provide support adjacent to joint, not to exceed 18". Provide sway brace on horizontal piping at not more than 40' intervals to prevent horizontal movement. Provide support at each horizontal branch.
2. Support all sizes of vertical cast iron piping every ten feet.
3. Support piping within 12" of each elbow or tee.
4. Support each P-trap.

D. Support condensate piping located on roof with pre-engineered roof supports, pre-engineered roof supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping". Conform to the table above for maximum spacing of supports. Adjust pipe support to maintain minimum pipe slope.

3.8 INSTALLATION OF PIPING SPECIALTIES

A. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and:

1. as required by plumbing code;
2. at each change in direction of piping greater than 45 degrees;
3. at minimum intervals of 50' for piping 4" and smaller and 100' for larger piping;
4. at base of each vertical soil and waste stack.
5. Locate cleanouts to allow adequate clearance in appropriate direction for ease of use.

B. Cleanout Covers: Install floor and wall cleanout covers for concealed piping, types to match adjacent building finish.

C. Floor Cleanouts: Install in below floor building drain piping at minimum intervals of 50' for piping 4" and smaller and 75' for larger piping. Cleanouts shall have a full-size opening coordinated with pipe size or per code requirements.

1. Install floor cleanouts in waterproof floors with waterproof membrane securely flashed with cleanout body flashing clamp so that no leakage occurs between cleanout body and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

D. Exterior Cleanouts: Install exterior cleanouts in a 18" x 18" x 8" block of concrete, flush with finished grade. Include pipe sleeve through concrete to allow movement of concrete.

3.9 INSTALLATION OF FLOOR DRAINS

A. Install floor drains in locations indicated.

B. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.

C. Refer to architectural documents for floor slope requirements and set floor drain elevation to match.

D. Provide P-traps for drains connected to the sanitary sewer.

E. Install floor drains waterproof floors with waterproof membrane securely flashed with drain flashing clamp so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

F. Position drains so that they are level, accessible and easy to maintain.

3.10 INSTALLATION TRAP SEALS:

A. Install trap seals in accordance with manufacturer's written instructions and in locations indicated.

B. Make watertight seal using an adhesive type caulk along bottom of trap seal, if required by the manufacturer.

C. Employ a test plug for testing and remove before normal floor drain use. Clean inside of drain tailpiece and install trap seal after testing.

D. Do not touch elastomeric plug or allow contact with primer or solvent cement.

3.11 CONNECTIONS

A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by the plumbing code.

B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.12 FIELD QUALITY CONTROL

A. Inspections

1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the authority having jurisdiction.
2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to ensure compliance with the requirements of the plumbing code.
c. Reinspection: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspected by the plumbing official.
d. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test: Test drainage and vent system in accordance with the procedures of the authority having jurisdiction, or in the absence of a published procedure, as follows:

1. Test for leaks and defects all new drainage and vent piping systems and parts of existing systems, which have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.
3. Rough Plumbing Test Procedure: Except for outside leaders and perforated or open jointed drain tile, test the piping of plumbing drainage and venting systems upon completion of the rough piping installation. Tightly close all openings in the piping system, and fill with water to the point of overflow, but not less than 10 feet head of water. Water level shall not drop during the period from 15 minutes before the inspection starts or a minimum of one hour, through completion of the inspection. Inspect all joints for leaks.
4. Final Plumbing Test Procedure: After the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proved gas and water-tight. Tightly close all openings, initially except vents thru the roof, in the system and fill the system with smoke from one or more smoke machines designed for smoke testing of plumbing systems. When smoke appears at a vent thru the roof, seal the vent thru roof with a test plug. Pressurize the system with 1" water column of smoke for 15 minutes. Use a "U" tube or manometer inserted in the trap of a water closet to measure this pressure. Visually verify all joints for leaks.
5. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.
6. Reports: Prepare inspection reports and required corrective action signed by the plumbing official and turn over to the Architect upon completion of the project.

A. Piping Test: Test the sanitary drainage and vent systems by filling with water with all points in the system being subjected to pressure of at least 10' of water. Water level shall remain stationary for a period of one hour, without any joint leakage.

B. Final Flow Verification test: Provide final flow verification documentation, within 10 days of Owner final acceptance of the facility. Test shall consist of providing 1500-gallon water tank and discharging through a 2-1/2" diameter hose by gravity into the main vent cleanout to verify no blockage of sewer system. Water flow shall not be throttled other than 2-1/2" diameter hose.

C. Smoke Test: Provide smoke testing of all drainage and vent systems within building when complete to confirm that all traps work properly and that all vents on roof do not recirculate into HVAC equipment outside air intake openings. Smoke test procedures are as follows:

1. Coordinate with general contractor for HVAC equipment to operate in economizer mode during the test.
2. Start at nearest manhole exterior to building by plugging manhole outlet pipe.

3. Light smoke bomb within manhole and blow air into the manhole via blower/fan located at the top of the manhole to push smoke into the sanitary drainage and vent system. Seal opening around blower/fan and manhole to prevent smoke from escaping.
4. With smoke being introduced into the sanitary drainage and vent system, observe smoke flow pattern from vents on roof. Check all interior spaces for smoke.
5. If leaks are observed, repair leaks and repeat the test. Continue testing and repairs until no leaks are observed.
6. Do not perform this test on a windy day.
7. Utilize consultant with experience in performing smoke tests. Contact Architect/Engineer's office for observation of testing. Submit final results to Architect/Engineer's office for their records.

3.13 ADJUSTING AND CLEANING

A. Clean interior of piping system. Remove dirt and debris as work progresses.

B. Clean drain strainers, domes, and traps. Remove dirt and debris.

3.14 PROTECTION

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

END OF SECTION

SECTION 221313 - FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 3500 Sanitary Sewers of the City of Lee's Summit, Missouri Standard Specifications

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Detail precast concrete manholes and vaults and indicate dimensions, method of field assembly, and components.

1.3 SUMMARY

A. This section Includes waste water piping and related components outside of the building. All private work shall be in accordance with Section 3500 Sanitary Sewers of the City of Lee's Summit, Missouri Standards Specifications, Current Edition:
1. Pipe and fittings.
2. Cleanouts.
3. Manholes.
4. Grease interceptors.

1.4 DELIVERY, STORAGE, AND HANDLING

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

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

1.5 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

A. PVC Type PSM Sewer Piping Complying with Section 3501.C1 of the City of Lee's Summit, Missouri Standard Specifications:

1. Pipe: ASTM D 3034 and F1336, SDR 26 PVC sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034 and F1336, PVC with bell ends except as amended in Section 3501 of the City of Lee's Summit Standard Specifications.
3. Gaskets: ASTM F 477, elastomeric seals.

B. PVC Pressure-Rated Pipe (SDR Series) Sewer Piping Complying with Section 3501.C2 of the City of Lee's Summit, Missouri Standard Specifications:
1. Pipe: ASTM D 1784 and F1336, SDR 26 PVC sewer pipe with bell-and-spigot ends for gasketed joints ASTM D3212.

2. Fittings: shall be DI and shall conform with Section 3501.D of the City of Lee's Summit Standard Specifications.
3. Gaskets: ASTM F 477, elastomeric seals.

C. Ductile Iron Pipe (DIP) and Fittings Complying with Section 3501.D of the City of Lee's Summit, Missouri Standard Specifications:
1. Pipe: ANSI/AWWA C150/A21.50 and C151/A21.51. The minimum thickness shall be Special Thickness Class 50.
2. Joints: Mechanical and push on joints shall conform to ANSI/AWWA C111/A21.11
3. Coatings, Linings and Polyethylene Encasement in accordacne with Section 3501.D 3 thru 4 of the City of Lee's Summit, Missouri Standard Specifications.

D. Casing Pipe Complying with Section 3501.O of the City of Lee's Summit, Missouri Standard Specifications

2.2 MANHOLES

A. Standard Precast Concrete Manholes in accordance with Section 3501.P of the City of Lee's Summit, Missouri Standard Specificaions.:
1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints. All concrete shall be corrosion resistant using ConShield or approved equal antimicrobial additive with contact colorant or approved equal added.
2. Diameter: 48 inches minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
4. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section; with separate base slab or base section with integral floor unless otherwise indicated.
5. Riser Sections: 4-inch minimum thickness, of length to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
7. Joint Sealant: Between precast sections, ASTM C 990, bitumen or butyl rubber. Exterior of Joints shall be sealed in accordance with Section 3501.P4 of the City of Lee's Summit, Missouri Standard Specifications.
8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
9. Steps: See plans and Section 3501 P8 of the City of Lee's Summit, Missouri Standard Specifications.

10. Adjusting Rings: HDPE or Concrete in accordance with Section 3501 P1.f of the City of Lee’s Summit, Missouri Standard Specifications.

B. Manhole Frames and Covers:
   1. See plans and City of Lee’s Summit Standard Details.

2.3 CLEANOUTS

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

2.4 CONCRETE

General: Cast-in-place concrete shall comply with Section 3501.F of the City of Lee’s Summit, Missouri Standard Specifications.

A. Portland Cement Design Mix: Refer to 3501.F.
   1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
   2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 deformed steel.

B. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 45000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
   1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
      a. Invert Slope: 2 percent through manhole.
   2. Benches: Concrete, sloped to drain into channel.
      a. Slope: 8 percent.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving". For additional information reference Section 3502 B and 2100 of the City of Lee’s Summit, Missouri Standard Specification.

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

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

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure, drainage piping according to the following:
1. Install piping pitched down in direction of flow, at minimum slope of 1 percent unless otherwise indicated.
2. Install piping 6” and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
3. Install piping with 42” minimum cover.
4. Install ductile-iron, gravity sewer piping according to ANSI/AWWA C 600.
5. Install PVC Type PSM sewer piping according to ASTM D 2321.

G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

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

B. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
1. Use nonpressure flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
a. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.4 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 301.

3.5 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.

B. Set cleanout frames and covers in concrete with tops 1 inch above surrounding grade as noted on project plans.

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

3.6 CONNECTIONS

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

B. Make connections to existing piping and underground manholes.
   1. Use commercially manufactured tee fittings for piping branch connections. Remove section of existing pipe, install tee fitting into existing piping, and encase entire wye fitting plus 6-inch overlap with not less than 6 inches of MCIB/KCMMB concrete with 28-day compressive strength of 4000 psi.

3.7 CLOSING ABANDONED SANITARY SEWER SYSTEMS

A. As noted on the plans and in accordance with Section 3502 B.13 of the City of Lee's Summit, Missouri Standard Specifications

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

3.8 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
   1. Use detectable warning tape over ferrous piping.
   2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.9 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project. Acceptance Tests for Completed Sewer shall be in accordance with Section 3502 C of the City of Lee's Summit, Missouri Standard Specifications.
   1. Submit separate report for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Section 3502 C.2.
      c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping. Section 3502 C.3
      e. Exfiltration: Water leakage from or around piping. Section 3502 C.3
   3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
   4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction. Refer to Section 3502 C of the City of Lee’s Summit, Missouri Standard Specifications.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Manholes: Perform Test in accordance with Section 3502 E of the City of Lee’s Summit, Missouri Standard Specifications.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

3.10 CLEANING

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

END OF SECTION 221313

SECTION 221400 - STORM DRAINAGE PIPING AND SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes building storm drainage piping systems, including drains and drainage specialties.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "General Plumbing Requirements," for trenching and backfilling materials and methods for underground piping installations.
2. Division 33 Section "Storm Systems," for storm drainage piping beginning from 5'-0" outside the building.
3. Division 33 Section "Foundation Drainage," for foundation drainage piping.
4. Division 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
5. Division 22 Section "Identification for Plumbing Piping and Equipment," for labeling and identification of drainage piping.
6. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations, wall and floor penetrations and equipment pads
7. Division 22 Section "Basic Piping Material and Methods," for materials and methods for mechanical sleeve seals.
8. Division 22 Section "Hangers and Supports for Plumbing Piping," for materials and methods for hanging and supporting drainage piping.
9. Division 22 Section "Plumbing Insulation," for materials and methods for insulating drainage piping.

1.2 DEFINITIONS

A. Storm Building Drain: That part of the lowest piping of a drainage system which receives the discharge from storm drainage pipes inside the walls of the building and conveys it to the building sewer.

B. Storm Building Sewer: That part of the drainage system which extends from the end of the building drain and conveys its discharge to a public sewer or private sewer or other point of disposal.

C. Drainage System: Includes all the piping within a public or private premises which conveys storm water or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specifications Sections.

B. Product data for the following products:

1. Drainage piping
2. Drainage piping specialties
3. Trench drains
4. Roof drains
5. No-hub fitting restraints

C. Test reports specified in Part 3 of this Section.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

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

1. Drainage Piping Specialties, including cleanouts, roof drains, and downspout nozzles:

    a. Josam Mfg. Co.
    b. Sioux Chief Manufacturing Co. Inc.
    c. Smith (Jay R) Mfg. Co.
    d. Tyler Pipe/Wade Div.; Subs. of Tyler Corp.
    e. Watts Industries, Inc.
    f. Zurn Industries, Inc.; Hydromechanics Div.
    g. Zurn Industries, Inc.

    h. Watts Industries, Inc.

2. Heavy Duty Hubless Couplings

    a. Anaco Husky HD-2000
    b. Clamp-All 80in. lb.
    c. Ideal Tridon "HD"
    d. Mission Rubber Company "Heavyweight"
    e. ProFlo "HD"

3. Downspout Boots

    a. Construction Castings Company
    b. Flockart
    c. Higgins Foundry
    d. Neenah Foundry Company

4. Cast Iron Soil Pipe and Fittings

    a. AB & I Foundry
    b. Charlotte Pipe and Foundry Company
    c. Tyler Pipe / Soil Pipe Division

5. Shielded Transition Couplings

    a. FERNCO, "Proflex 3000 Series"
    b. Mission Rubber Company, "Band Seal Specialty Couplings"

6. Underground Shielded Adapter Couplings

    a. FERNCO, "1056 Series with SR73 Shear Ring"
    b. Mission Rubber Company, "MR56 Series"

7. PVC DWV Fittings 16" and Larger

    a. Plastic Trends, Inc.

8. No-Hub Fitting Restraints

    a. Holdrite

2.2 ABOVE GROUND DRAINAGE PIPE AND FITTINGS

A. Cast-Iron Soil Pipe: CISPI 301 and ASTM A888, hubless pipe and fittings, and bearing the trademark of CISPI and NSF.

    1. Heavy duty couplings and compression gaskets: ASTM C1540 and meeting FM 1680.

B. Shielded Transition Couplings: ASTM C1460 with neoprene adapter gasket with stainless steel Shield and hose clamps.

2.3 UNDERGROUND BUILDING DRAIN PIPE AND FITTINGS

A. PVC DWV Pipe and Fittings: Schedule 40 pipe meeting ASTM D1785 and ASTM D2665 with "solid wall" PVC meeting ASTM D1784 with cell class 12454-B.

    1. Fittings: DWV pattern meeting ASTM D2665 with solvent cement socket joints.
    2. Solvent: ASTM D2564.

B. Underground Shielded Adapter Couplings: ASTM C1173 with neoprene adapter gasket with stainless steel shield and stainless steel hose clamps.

2.4 DRAINAGE PIPING SPECIALTIES

A. Cleanout Plugs: Cast-bronze or brass, threads complying with ANSI B2.1, countersunk head.

B. Floor Cleanouts: Cast-iron Body and frame, cleanout plug, adjustable nickel-bronze top, exposed flush type, standard non-slip scored or abrasive finish.

C. Wall Cleanouts: Cast-iron body adaptable to pipe with cast-bronze or brass cleanout plug, stainless steel cover, including screws.

D. Roof Drains: As specified on the drawings.

E.

2.5 NO-HUB FITTING RESTRAINTS

A. Pre-engineered kits of galvanized steel pipe straps with stainless steel band clamps and tee bolts, meeting requirements of the CISPI Installation Handbook.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install pipe and specialties in accordance with manufacturer's installation instructions.

3.2 PREPARATION FOUNDATION FOR UNDERGROUND BUILDING DRAINS

A. Pipe Beds:

1. PVC and ABS Pipe: Support pipe in trench with sand bags level and true to prevent sand, gravel or debris from interfering with the solvent cement process. After pressure testing is complete, gradually install bedding to maintain continuous pipe slope and prevent pipe deflection and then install subbase. Refer to Section "General Plumbing Requirements" for bedding and subbase materials, excavation, trenching, backfill and compaction requirements and refer to ASTM D2321 "Underground Installation of Thermoplastic Pipe for Sewers and Gravity-flow Applications" for additional requirements.

3.3 PIPE APPLICATIONS - ABOVE GROUND, WITHIN BUILDING

A. Install hubless, cast-iron soil pipe and fittings 15" and smaller for storm pipe.

3.4 PIPE APPLICATIONS - BELOW GROUND, WITHIN BUILDING

A. Install PVC Type DWV Plastic pipe and fittings for 24 inch and smaller storm pipe. Install fabricated fittings for 16 inch and larger.

3.5 PIPE AND TUBE JOINT CONSTRUCTION

A. Copper Tubing: Solder joints in accordance with the procedures specified in AWS "Soldering Manual."

B. Cast-Iron Soil Pipe: Make hubless joints in accordance with the Cast-Iron Soil Pipe & Fittings Handbook, Chapter IV. Install Couplings as followings:

1. Install heavy duty hubless couplings on storm drainage piping, including connections to roof drains.
2. Install No-Hub fitting restraints on joints 5" and larger at:

a. Changes of direction from vertical to horizontal
b. 4" branch connections, including tees, wyes and wye combination fittings to storm drainage piping 5" and larger

c. Horizontal changes of direction 22-1/2 degrees and greater

C. PVC DWV Pipe: Joining and installation of PVC drainage pipe and fittings shall conform to ASTM D2665.

D. ABS to PVC Transition Joints: When joining ABS to PVC components (such as an ABS building drain to PVC sewer pipe) make joints using solvent cements conforming to ASTM D3138.

E. Cast Iron to PVC Above Grade: Join cast iron to PVC with shielded transition couplings.

F. Cast Iron to PVC Below Grade: Join cast iron to PVC with underground shielded adapter couplings.

3.6 INSTALLATION

A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing, slope, expansion, and other design considerations. So far as practical, install piping as indicated.

B. Use fittings for all changes in direction and all branch connections.

C. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

D. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

E. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

F. Install horizontal piping as high as possible allowing for proper slope and coordination with other components. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

G. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and sealer. Refer to Division 22 Section "Basic Piping Materials and Methods" for special sealers and materials.

H. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings and floors, maintain the fire rated integrity. Refer to Division 22 Section "Common Work Results for Plumbing" for special sealers and materials.

I. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of Non-Fire Rated Walls and Concrete Slab on Grade Penetrations: Provide sleeves and seal pipes that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 22 Section "Common Work Results for Plumbing" for special sealers and materials.

J. Foundation Penetrations: Where pipes pass through foundation walls above strip footings or under strip footings, protect pipes from building load with cast iron soil pipe sleeves two pipe sizes larger than the pipe. Sleeves installed under the strip footing shall be encased in concrete.

K. Make changes in direction for drainage piping using appropriate 45 degree wyes, combination wye and eighth bend, or long sweep, quarter, sixth, eighth, or sixteenth bends. Sanitary tees or quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn pattern combination wye and eighth bends where two fixtures are installed back to back and have a common drain. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper sized standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

L. Install underground building drains to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

M. Install drainage piping pitched down at a minimum slope of 1/4 inch per foot (2 percent) for piping 3 inch and smaller, and 1/8 inch per foot (1 percent) for piping 4 inch and larger.

3.7 HANGERS AND SUPPORTS

A. General: Hanger, support, insulation protection shields, and anchor components and installation procedures conforming to MSS SP-58 and SP-69 are specified in Division 22 Section "Hangers and Supports for Plumbing Piping". Conform to the table below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable clevis hangers, MSS SP-69 Type 1, for individual horizontal runs.
2. Riser clamps, MSS SP-69 Type 8, for individual vertical runs.
3. Insulation protection shields and high density insulation at each hanger for insulated pipe as specified in Division 22 Sections "Hangers and Supports for Plumbing Piping" and "Plumbing Insulation".

    a. Install high density insulation on insulated pipe.

4. Provide vinyl coated hangers and riser clamps for use with PVC pipe.

C. Install hangers at the following intervals and provide rods of diameter as listed below:

Nom. Pipe Size	Steel Pipe Max. Span	Copper Tube Max. Span.	Min. Rod Dia. - Inches Steel or
In Inches	In Feet	In Feet	Cast Iron
2	10	8	3/8
3	12	10	1/2
4	14	12	5/8
5	16	13	5/8
6	17	14	3/4
8	19	16	7/8
10	22	18	7/8
12	23	19	7/8

1. Support all sizes of hubless horizontal cast iron piping every five feet, except up to ten feet where ten foot sections are installed. Support all sizes of hubless horizontal cast iron piping every other joint, unless over four feet, then support each joint. Provide support adjacent to joint, not to exceed 18". Provide sway brace on horizontal piping at not more than 40' intervals to prevent horizontal movement. Provide support at each horizontal branch.
2. Support all sizes of vertical cast iron piping every ten feet.
3. Support piping within 12" of each elbow or tee.

3.8 INSTALLATION OF PIPING SPECIALTIES

A. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and:

1. as required by plumbing code;
2. at each change in direction of piping greater than 45 degrees;
3. at minimum intervals of 50' for piping 4" and smaller and 100' for larger piping;
4. at base of each vertical soil, waste, or storm water stack.
5. Locate cleanouts to allow adequate clearance in appropriate direction for ease of use.

B. Cleanout Covers: Install floor and wall cleanout covers for concealed piping, types to match adjacent building finish.

C. Floor Cleanouts: Install in below floor building drain piping at minimum intervals of 50' for piping 6" and smaller and 75' for larger piping. Cleanouts shall have a full size opening coordinated with pipe size or per code requirements.

1. Install floor cleanouts in waterproof floors with waterproof membrane securely flashed with cleanout body flashing clamp so that no leakage occurs between cleanout body and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.

D. Exterior Cleanouts: Install exterior cleanouts in a 18" x 18" x 8" block of concrete, flush with finished grade. Include pipe sleeve through concrete to allow movement of concrete.

3.9 INSTALLATION OF ROOF DRAINS

A. Install roof drains at low points of roof areas with the roof membrane securely flashed with drain flashing clamp so that no leakage occurs between drain and roof membrane.

B. Install drain flashing collar or flange so that no leakage occurs between roof drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.

C. Position roof drains so that they are accessible and easy to maintain.

3.10 FIELD QUALITY CONTROL

A. Inspections

1. Do not enclose, cover, or put into operation the storm drainage piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

    a. Rough-in Inspection: Arrange for inspection of the storm drainage piping system before concealed or closed-in after system is roughed-in.
    b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the plumbing code.
    c. Reinspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspected by the plumbing official.
    d. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test: Test storm drainage system in accordance with the procedures of the authority having jurisdiction, or in the absence of a published procedure, as follows:

1. Test for leaks and defects all new storm drainage piping systems and parts of existing systems, which have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.
3. Rough Plumbing Test Procedure: Except for outside leaders and perforated or open jointed drain tile, test the piping of storm drainage piping systems upon completion of the rough piping installation. Tightly close all openings in the piping system, and fill with water to the point of overflow, but not less than 10 feet head of water. Water level shall not drop during the period from 15 minutes before the inspection starts, through completion of the inspection. Inspect all joints for leaks.
4. Repair all leaks and defects using new materials and retest system or portion thereof until satisfactory results are obtained.
5. Reports: Prepare inspection reports and required corrective action signed by the plumbing official and turn over to the Architect upon completion of the project.

3.11 ADJUSTING AND CLEANING

A. Clean interior of piping system. Remove dirt and debris as work progresses.

B. Clean drain strainers and domes. Remove dirt and debris.

3.12 PROTECTION

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

END OF SECTION

SECTION 221500 - GENERAL SERVICE COMPRESSED AIR SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes piping, equipment, and related accessories, for general building, compressed air systems operating at 200 psig and below.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 3 Section "Concrete Work" for specifications on concrete and reinforcing materials and concrete placing requirements for equipment pads.
2. Division 7 Section "Joint Sealants," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
3. Division 22 Section "Coordination" for basic requirements for electrical components that are an integral part of packaged system components.
4. Division 22 Section, "Common Work Results for Plumbing" for materials and methods for fire barrier penetrations, wall and floor penetrations and concrete equipment pads.
5. Division 22 Section "Basic Piping Materials and Methods" for flexible metal braid connectors, pipe joining materials, specialties, unions, dielectric unions, dielectric flanges, dielectric flange kits and basic installation requirements.
6. Division 22 Section "Meters and Gauges for Plumbing Piping" for thermometers, pressure gauges, and fittings.
7. Division 22 Section "Hangers and Supports for Plumbing Piping" for equipment and piping hangers and supports.
8. Division 22 Section "Vibration Isolation for Plumbing Piping and Equipment" for inertia pads, isolation pads, spring supports, and spring hangers.
9. Division 22 Section "Seismic Controls for Plumbing Piping and Equipment" for field-installed seismic restraint devices used for equipment and piping systems.
10. Division 26 Section "Common Work Results for Electrical" required electrical devices.
11. Division 26 Sections "Enclosed Switches and Circuit Breakers" for field-installed disconnects.

1.2 DEFINITIONS

A. Low-Pressure Compressed Air Systems: ASME B31.9 "Building Services Piping" for systems operating at pressure of 125 psig or less, and temperature 200 deg F or less.

B. Medium-Pressure Compressed Air Systems: ASME B31.1 "Power Piping" for systems operating at pressure between 125 psig and 200 psig, or operating at temperature of more than 200 deg F.

C. High-Pressure Compressed Air Systems: ASME B31.1 "Power Piping" for systems operating at pressure greater than 200 psig.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories for all equipment; indicating dimensions, required clearances, and methods of assembly of components, and piping and wiring connections.

C. Wiring diagrams from manufacturers detailing electrical requirements for electrical power supply wiring to equipment. Include 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 field-installed.

D. Certificates of shop inspection and data report as required by provisions of the ASME Boiler and Pressure Vessel Code.

E. Coordination drawings for compressed air systems in accordance with Division 22 Section "General Plumbing Requirements."

F. Maintenance data for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 22 Section "General Plumbing Requirements."

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: NFPA 70 "National Electrical Code."

B. Listing and Labeling: Provide equipment that is listed and labeled.

1. Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

3. Furnish control panels manufactured in accordance with UL 508A.

C. ASME Code Compliance: Provide system components complying with the following:

1. Receiver Tanks: Comply with ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels, and bear the appropriate code symbols.
2. Safety Valves: ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels, National Board certified, bear the appropriate labeling, and have been factory-sealed after testing.

3. Low-Pressure Systems Piping: ASME B31.9, Building Services Piping.

D. Pipe, pipe fittings and pipe specialties shall be manufactured in plants located in the United States or certified to meet the specified ASTM and ANSI standards.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

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

1. Splash Lubricated, Reciprocating Air Compressors:

    a. Champion Pneumatic Machinery Co., Inc.
    b. Gardner-Denver Products, Industrial Machinery; Cooper Industries.
    c. Ingersoll-Rand Co.
    d. Powerex.
    e. Quincy Compressor Div.; Coltec Industries, Inc.
    f. Saylor-Beall Manufacturing Co.

2. Air Dryers:

    a. Arrow Pneumatics, Inc.
    b. Champion Pneumatic Machinery Co., Inc.
    c. Deltech Engineering, L.P.
    d. Hankison Div.; Hansen, Inc.
    e. Ingersoll-Rand Co.
    f. Saylor-Beall Manufacturing Co.
    g. Sullair Corp. Subsid.; Sundstrand Corp.
    h. Ultrafilter, Inc.
    i. Van Air Systems, Inc.
    j. Zeks Air Drier Corp.

3. Air Filters:

    a. Deltech Engineering, L.P.
    b. Hankison Div.; Hansen, Inc.
    c. Ingersoll-Rand Co.
    d. Ultrafilter, Inc.
    e. Zurn Industries

4. Air Regulators & Lubricators:

    a. Arrow Pneumatics, Inc.
    b. Champion Pneumatic Machinery Co., Inc.
    c. Wilkerson.

5. Automatic Drain Valves:

    a. Arrow Pneumatics, Inc.
    b. Deltech Engineering, L.P.
    c. Ingersoll-Rand Co.
    d. Zurn Industries

6. Quick Connect/Disconnect Hose Couplings:

    a. Aeroquip Corp.; Industrial Connectors Div.
    b. Bowes Manufacturing, Inc.
    c. Amflo Products Div.; Bridge Products Inc.
    d. Foster Manufacturing Co., Inc.
    e. Graco Inc, North America
    f. Hansen Coupling Div.; Tuthill Corp.
    g. Milton Industries, Inc.
    h. OBAC Corp.
    i. Schrader Automotive, Inc.
    j. Snap-Tite, Inc.

7. Air Hose Reels

   a. COXREELS
   b. Hannay Reels, Inc.
   c. Reelcraft Industries

8. Ball Valves – 2" and smaller:

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	77C-100	77C-200
Hammond	8301A	8311A
Milwaukee	BA-400	BA-450
Nibco	T-585-70	S-585-70

9. Ball Valves – 2" to 4":

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	82-100	82-200
Hammond	8604	8614
Milwaukee	BA-300	BA-350
Nibco	T-595-Y	S-595-Y

10. Check Valves – 2" and smaller:

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	161S	161T
Hammond	IB940	IB945
Milwaukee	509-T	1509-T
Nibco	T-413-Y	S-413-Y

11. Check Valves – 2" to 4":

MANUFACTURER	
Apollo	910F
Hammond	IR1124
Milwaukee	F2974
Nibco	F-918-B

2.2 PIPE AND TUBE MATERIALS

A. Copper Tube: ASTM B 88, Type K or Type L, Seamless, Water Tube, hard-drawn temper.

B. Copper Tube: ASTM B 88, Type K or Type L, Seamless, Water Tube, hard-drawn temper, factory-cleaned, purged, and sealed, and marked or labeled "cleaned for medical gas service," "cleaned for oxygen service," "acr/oxy," or "nitrogenized.".

2.3 PIPE AND TUBE FITTINGS

A. Copper Tube Fittings: ASME B16.22, wrought copper or copper alloy, solder-joint, pressure type.

B. Bronze Tube Flanges: ASME B16.24, Classes 150 and 300.

C. Copper Tube Fittings: ASME B16.22, wrought copper or copper alloy, solder-joint, pressure type, factory-cleaned, purged, and sealed, and marked or labeled "cleaned for medical gas service," "cleaned for oxygen service," "acr/oxy," or "nitrogenized."

2.4 VALVES

A. Ball Valves, 2 Inch and Smaller: MSS SP-110, Class 150 saturated steam pressure, 600-psi CWP; two-piece construction; with bronze body conforming to ASTM B 584, full port, chrome-plated brass ball, replaceable PTFE (Teflon) seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends for use with copper tubing or threaded ends for use with steel piping. Provide Class 150 valves meeting the above where system pressure requires. Provide with side vented ball where required.

B. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, 200-psi CWP, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and PTFE (Teflon) disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150, 300-psi CWP, valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

2.5 JOINING MATERIALS

A. Screwed Joint Pipe Tape: Polytetrafluoroethylene (PTFE) plastic.

B. Gasket Material: ASME B16.21, nonmetallic, flat, asbestos-free composition.

C. Solder Filler Metal: ASTM B 32, Alloy Sb5 (95 percent tin and 5 percent antimony), with 0.20 percent maximum lead content.

D. Brazing Filler Metals: AWS A5.8, AWS A5.8, BAg-5, with a cadmium content of zero.

E. Brazing Filler Metals: AWS A5.8, AWS A5.8, BCuP-5, with a minimum silver content of 15%. Flux is prohibited.

2.6 DUPLEX RECIPROCATING AIR COMPRESSORS

A. Provide factory-assembled and tested, duplex, packaged, air-cooled, continuous duty, piston-type, motor-driven air compressors as indicated, of capacities and having electrical characteristics indicated on the drawings, and with the following features:

1. Belt guards totally enclosing pulleys and belts.
2. Receivers: 150psi ASME-code-construction horizontal receiver with safety valve, pressure gauge, and automatic drain.
3. Inlet silencer filters
4. Safety valves
5. Shutoff valve.

B. Controls: NEMA 1 enclosure, lockable combination circuit breaker magnetic motor starter and 3 leg overload protection for each motor, compressor hand-off-automatic selector switches, overload relays, resets, automatic alternator for alternating lead-lag compressor selection and to provide for both compressors to operate simultaneously under high load condition, low oil level

shutdown switch and alarm light, high temperature shutdown switch and alarm light and run time clock for each compressor. Circuit breakers shall have minimum AIC rating as indicated on the Electrical Drawings. Control panel shall have a unit short circuit current rating equal to or greater than the available short circuit current as indicated on the electrical drawings. Controls shall be configured for terminating one incoming power feeder.

C. Disconnect: Disconnect is provided under Division 26.

D. Tank-Mounted, Reciprocating Air Compressors: Two stage, single acting, splash lubricated with centrifugal unloader for loadless starting, crank shaft roller bearings and belt guard mounted air cooled aftercooler. Each compressor shall be equipped with a belt driven, high efficiency, dripproof, continuous duty, ball bearing, induction type motor mounted on adjustable slide base and provided with a totally enclosed drive guard.

E. Air Dryers, Refrigerated Type: Provide with capacities and characteristics as indicated on the drawings. Equip with drain connection.

F. Filters and regulators: Air line filtration system for removal of liquids and particulate matter shall include coalescing prefilter with automatic drain, particulate filter and final charcoal adsorption filter, air line pressure regulators with gauges, final pressure relief valve installed on discharge side of air dryers.

2.7 AIR DRYERS

A. Air Dryers, Refrigerated Type: Provide with capacities and characteristics as indicated on the drawings. Equip with drain connection.

2.8 ACCESSORIES

A. General: Provide accessories having working pressure rating not less than system pressure at location where used, and compatible with equipment and piping system used.

B. Intercoolers: Air-cooled, fixed-bundle, tubular intercoolers, rated at 250 psig and leak-tested at 350-psig minimum air pressure, in capacities indicated. Size units to cool compressed air in compressor-rated capacities to 10 deg F above summertime maximum ambient temperature.

C. Separators: Conical shaped, centrifugal air-line separators in sizes and capacities indicated. Equip with water-removal trap and drain. Size units for maximum pressure drop through units of 3 psig from air inlet to outlet.

D. Receivers: ASME stamped, cylindrical, vertical or horizontal installation as indicated, galvanized steel; with safety valves in sizes, working pressures and temperatures indicated, and with drain connection.

1. Pressure rating: Not less than maximum discharge pressure.

E. Safety Valves: ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels construction, National Board certified, labeled, and factory-sealed; constructed of bronze body with poppet safety valve for compressed air service.

1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

F. Pressure Regulators: Bronze body, direct-acting, spring-loaded, manual pressure setting adjustment, and rated for 250-psig inlet pressure except where otherwise indicated.

1. Type: Diaphragm-operated.

G. Pressure Regulators (Reducing Valves): Aluminum alloy or plastic body, diaphragm-operated, direct-acting, spring-loaded, manual pressure setting adjustment, and rated for 250-psig inlet pressure except where otherwise indicated.

H. Filters: Capacities and types indicated on the drawings. Equip with cartridges capable of removing particles, water and oil aerosols, and with warning light to indicate when selected maximum pressure drop has been exceeded with characteristics indicated on the drawings.

I. Automatic Drain Valves: Electronic controlled corrosion-resistant metal body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate.

J. Hose, Clamps, and Couplings: Provide compatible hose, hose clamps, and hose couplings, suitable for compressed air service, of nominal diameter, and rated for 300-psig minimum working pressure except where otherwise indicated.

1. Quick Connect/Disconnect Hose Couplings: One-way, automatic shutoff, brass body, with O-ring or gasket seal, and stainless steel or nickel-plated steel operating parts. Select socket end with threaded inlet that is considered the fixed end and has a one-way valve.

a. Plug End: Flow-sensor bleeder, check-valve type, with serrated outlet for hose.

2. Quick Connect/Disconnect Hose Couplings: Straight through, brass body, with stainless-steel or nickel-plated steel operating parts. Select socket end with O-ring or gasket seal, and without valve. Select socket and plug ends with serrated outlets for hose.
3. Hose Coupling: Two-piece, threaded, brass or stainless steel, O-ring or gasket seal, swivel coupling, with serrated ends, 300-psig minimum working pressure.
4. Hose Adapter: One-piece, brass or stainless-steel fitting, with serrated ends.
5. Hose: Reinforced, single- or double-braid, neoprene-covered hose, for compressed air service.
6. Hose Clamps: Stainless steel, clamps, bands, or wire.

K. Air Hose Reels: As specified on the drawings.

PART 3 - EXECUTION

1.1 INSTALLATION, GENERAL

A. Install air compressors, air dryers, accessories, piping, valves and specialties in accordance with manufacturer's installation instructions.

3.1 CONCRETE EQUIPMENT BASES

A. Refer to Division 22 Section "Common Work Results for Plumbing" for concrete equipment bases.

1. Form concrete equipment bases by using framing lumber with form release compounds. Chamfer top edge and corners of pad.

2. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves using manufacturer's installation template.
3. Place concrete and allow to cure before installation of pumps.

3.2 EQUIPMENT INSTALLATION

A. Install air compressors on concrete bases. Set and connect units in accordance with manufacturers' written installation instructions. Install units plumb and level, firmly anchored, in locations indicated, and maintain manufacturers' recommended clearances. Orient so equipment controls and devices needing servicing are accessible. For indirect drain material and installation.

B. Install seismic restrains for equipment as indicated refer to Division 22 Section "Seismic Controls for Plumbing Piping and Equipment".

C. Install flexible connectors where indicated on the drawings. Refer to Division 22 "Basic Piping Material and Methods" for installation.

D. Install indirect drains on air compressor accumulator tank drain valve, air dryer condensate drain and each automatic air drain valve and route to nearest floor drain. Refer to Division 22 Section "Sanitary Drainage and Vent Piping and Specialties".

E. Provide equipment pad and vibration isolation, refer to Division 22 Section "Vibration Isolation For Plumbing Piping & Equipment".

F. Provide equipment pad, concrete inertia base and vibration isolation, refer to Division 22 Section "Vibration Isolation For Plumbing Piping & Equipment".

3.3 PIPING APPLICATIONS

A. Low-Pressure Systems: Use the following pipe and fittings:
1. 2 Inches and Smaller: Copper tube with copper and copper alloy solder fittings; soldered joints.

B. Medium-Pressure Systems: Use the following pipe and fittings:
1. 4 Inches and Smaller: Copper tube, copper fittings, and Class 300 bronze tube flanges; brazed and flanged joints.

3.4 JOINT CONSTRUCTION

A. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe tape, suitable for the service for which the pipe is intended, on the male threads at each joint. Tighten joint to leave not more than 3 threads exposed.

B. Welded Joints: Weld pipe joints in accordance with ASME Code for Pressure Piping, B31.9 Building Service Piping for low-pressure systems and B31.1 Power Piping for medium-pressure systems.

C. Brazed and Soldered Joints: For copper tube and fittings, braze and solder joints in accordance with ASME B31 - Standard Code for Pressure Piping.

1. Braze joints in accordance with ASME B31.1 - Power Piping with BAg-5 brazing filler metal

2. Solder joints in accordance with ASME B31.9 - Building Service Piping.
3. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
4. Mechanical Joints: Follow grooved-end mechanical coupling manufacturer's written instructions.

D. All brazing shall be done with dry nitrogen flowing through the pipe to prevent oxidation and scale formation. Flow rate shall be 0.5 cfm for ½" tube and 1 cfm for ¾" tube.

3.5 VALVE APPLICATIONS

A. General-Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shut-off duty - 2" and smaller: Use 2-piece ball valves.

a. Provide side vented ball valves only at individual equipment connections and air drops to relieve air downstream of ball valve when closed for equipment repair or removal.

3.6 INSTALLATION OF VALVES

A. Sectional Valves: Install sectional valves on each branch and riser, close to main, and elsewhere as indicated.

B. Shutoff Valves: Install shutoff valves on outlet of each compressed air equipment item, on each supply to each compressed air outlet, and elsewhere as indicated.

C. Locate valves for easy access and provide separate support where necessary. Provide access doors and fire rated access doors as required.

D. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

E. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

F. Install valves in horizontal piping with stem at or above the center of the pipe.

G. Install valves in a position to allow full handle rotation.

H. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.

3.7 PIPING INSTALLATION, GENERAL

A. Install air and drain piping with 1/8-inch-per-foot slope downward in direction of air flow.

B. Install eccentric reducers where pipe is reduced in size in the direction of flow, with bottoms of both pipes and reducer flush.

C. Connect branch air piping to mains from top of main. Provide drain leg and drain trap at end of each main, each branch, and each low point in piping system.

D. Install horizontal piping as high as possible. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

E. Install piping specialties in accordance with Division 22 Section "Basic Piping Materials and Methods."

F. Install supports and anchors in accordance with Division 22 Section "Hangers and Supports for Plumbing Piping."

1. Spacing: Do not exceed 10'-0" spacing between pipe hangers.

G. Install valves in accordance with Division 22 Section "General Duty Valves for Plumbing Piping."

H. Install thermometers and pressure gauges in accordance with Division 22 Section "Meters and Gauges for Plumbing Piping."

I. Exterior Wall Penetrations: Seal pipe penetrations through exterior wall constructions with sleeves packing, and sealant. Refer to Division 22 Section "Basic Piping Materials and Methods" for additional information.

J. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of Non-Fire Rated Walls and Concrete Slab on Grade Penetrations: Provide sleeves and seal pipes that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 22 Section "Common Work Results for Plumbing" for special sealers and materials.

K. Joints Containing Dissimilar Metals: Provide dielectric unions for 2" and smaller and dielectric flanges for piping 2-1/2" and larger. Dielectric unions and flanges are specified in Section "Basic Piping Materials and Methods".

L. Joints at Valve Assemblies: Provide unions downstream of shutoff valves at valve assemblies. Unions are not required at flanged connections. Unions are specified in Division 22 section "Basic Piping Materials and Methods".

3.8 HANGERS AND SUPPORTS

A. General: Hanger, support, insulation protection shield, and anchor components and installation procedures conforming to MSS SP-58 and SP-69 are specified in Division 22 Section "Hangers and Supports for Plumbing Piping." Conform to the table below for maximum spacing of supports.

B. Pipe Attachments: Install the following:

1. Adjustable band hangers, MSS SP-69 Type 7, for steel pipe for individual horizontal runs and for copper tube for horizontal runs.
2. Steel riser clamps, MSS SP-69 Type 8, for individual vertical runs of steel pipe.
3. Plastic coated adjustable band hangers with, MSS SP-69 Type 7, for copper tube for horizontal runs.
4. Plastic coated steel riser clamps, MSS SP-69 Type 8, for individual vertical runs of copper tube.

5. Extension split ring pipe clamp, MSS SP-69 Type 12, for individual vertical exposed runs of steel pipe 2" and smaller on walls or for securing steel pipe inside walls.
6. Copper coated extension split ring pipe clamp, MSS SP-69 Type 12, for individual vertical exposed runs of copper tube 2" and smaller on walls or for securing copper tube inside walls.
7. Provide roll hangers for individual horizontal runs 100 feet or longer.
8. Aluminum tubing system fixing clips, clamps, and hangers.

C. Install hangers for horizontal piping with the following maximum spacing and minimum rod sizes:

Nom. Pipe Size - In.	Steel Pipe Max. Span - Ft.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.
Up to 1-1/4	12	6	3/8
1-1/2 to 2	12	10	3/8

1. Support vertical steel pipe at each floor.
2. Support vertical copper tube at each floor and in intervals not to exceed 10 feet.

D. Support piping within 12" of each elbow or tee and for piping 2-1/2" and larger at each valve or strainer.

E. Support piping above the floor with pipe supports attached to the floor with anchor bolts where indicated on the drawings. Conform to the table above for maximum spacing of supports.

F. Provide vibration isolation for piping connected to rotating equipment. Vibration isolators are specified in Division 22 specification Section "Vibration Isolation for Plumbing Piping and Equipment".

3.9 CONNECTIONS

A. Install piping adjacent to equipment to allow servicing and maintenance.

B. Connect air piping to units with shutoff valves and unions.

1. Where air piping connections are dissimilar metals, install dielectric waterway fittings or dielectric unions for joints 2" and smaller and dielectric flanges for joints 2-1/2" and larger. Dielectric waterway fittings, unions and flanges are specified in Division 22 Section "Basic Piping Materials and Methods."
2. Install thermometers on compressor discharge piping, on receiver tanks, and where indicated.
3. Install pressure gauges on compressor discharge piping, on receiver tanks, and where indicated.

C. Connect water piping to intercooler and aftercooler units with union and reduced-pressure-zone-type backflow-preventer assembly having strainer, gate valves, and air gap fitting for indirect waste. Connect cooler unit drains with union and flow control valve, and discharge over closest floor drain.

1. Where air piping connections are dissimilar metals, install dielectric waterway fittings or dielectric unions for joints 2" and smaller and dielectric flanges for joints 2-1/2" and larger.

Dielectric waterway fittings, unions and flanges are specified in Division 22 Section "Basic Piping Materials and Methods."

D. Install safety valves in receiver tanks, in quantity and size to relieve capacity not less than that of connected compressor.

E. Install automatic drain valves on intercoolers, aftercoolers, separators, receivers, dryers, filters and other locations indicated. Discharge condensate over nearest floor drain.

F. Install flexible connectors where indicated in accordance with Division 22 Section "Basic Piping Materials and Methods".

G. Securely attach hose reels to the structure as specified in Division 22 Section "Hangers and Supports for Plumbing Piping."

H. Electrical Connections:

1. Power wiring is specified in Division 26 Section "Common Work Results for Electrical"
2. Field-installed disconnects are specified in Division 26 Sections "Enclosed Switches and Circuit Breakers".
3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.10 AIR HOSE REELS

A. Install horizontal hanging hose reels with "I" or "H" beam brackets

B. Install vertical hanging hose reels with swing brackets.

3.11 FIELD QUALITY CONTROL

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

1. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.

B. Piping System Tests: Cap and fill new and parts of existing systems that have been modified, with oil-free, dry air or gaseous nitrogen, to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate the test source and let stand for 4 hours to equalize temperature. Refill system, if required, to test pressure and hold pressure for 2 hours with no drop in pressure.

1. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

3.12 STARTUP

A. Preparation: Perform the following final checks before startup:

1. Complete tests of piping systems.

2. Check for piping connection leaks.
3. Check lubricating oil for lubricated-type equipment.
4. Check V-belts for proper tension.
5. Check that compressor inlet filters and piping are clear.
6. Check equipment vibration-control supports and flexible pipe connectors, and that equipment is properly attached to substrate.

7. Check for proper seismic restraints.
8. Check that safety valves have correct setting; greater than compressor discharge pressure, but not greater than pressure rating of system components.
9. Test operation of equipment safety controls and devices.
10. Check water supply to water-cooled equipment.
11. Check water supply to liquid-ring air compressors.
12. Drain receiver tanks.
13. Check for adequate room ventilation.

B. Starting Procedures: Follow the manufacturer's written procedures. If no procedures are prescribed by the manufacturer, proceed as follows:

1. Energize circuits.
2. Start and run equipment through complete sequence of operations.
3. Check for excessive vibration and noise. Correct problems.
4. Check air pressures.
5. Manually operate safety valves.
6. Adjust operating controls including pressure settings.

3.13 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of twohours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

SECTION 223300 - ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes electric water heaters.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 3 Section "Concrete Work" for specifications on concrete and reinforcing materials and concrete placing requirements for equipment pads.
2. Division 22 Section "Common Work Results for Plumbing" for concrete equipment pads.
3. Division 22 Section "Basic Piping Materials and Methods" for pipe joining materials, unions, dielectric unions, dielectric flanges, dielectric flange kits and basic installation requirements.
4. Division 22 Section "Meters and Gauges for Plumbing Piping." for thermometers and their installation requirements.
5. Division 26 Section "Common Work Results for Electrical" required electrical devices.
6. Division 26 Section "Enclosed Switches and Circuit Breakers" for field-installed disconnects.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories, and indicating dimensions, required clearances, and methods of assembly of components, and piping and wiring connections.
2. Wiring diagrams from manufacturers detailing electrical requirements for electrical power supply wiring to water heaters. Include ladder-type wiring diagrams for interlock and control wiring required for final installation of water heaters and controls. Differentiate between portions of wiring that are factory installed and portions that are to be field installed.
3. Maintenance data for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 22 Section "General Plumbing Requirements."

1.3 QUALITY ASSURANCE

A. UL Standards: Provide water heaters complying with the following:

1. UL 174, "Household Electric Storage Tank Water Heaters."

B. NSF Standards: Provide water heaters complying with NSF No. 5, "Standard for Hot Water Generating Equipment for Food Service Establishments using Spray Type Dishwashing Machines," and bearing NSF label.

C. Electrical Component Standard: Provide components complying with NFPA 70 "National Electrical Code."

D. Listing and Labeling: Provide water heaters that are listed and labeled.

1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.

E. State Boiler Code Compliance: Provide rated water heaters, safety relief valve and accessories that comply with the state boiler code in effect.

F. ASHRAE Standards: Provide water heaters with performance efficiencies not less than prescribed in ASHRAE 90.1b, "Energy Conservation in New Building Design."

G. Design Concept: The drawings indicate types and capacities of water heaters and are based on specific descriptions and manufacturers indicated. Water heaters having equal performance characteristics by other manufacturers may be considered provided that deviations in capacities, dimensions, operation, or other characteristics are minor and do not change the design concept or intended performance as judged by the Architect. Burden of proof for equality of water heaters is on the proposer.

1.4 WARRANTY

A. Special Project Warranty: Submit a written warranty, executed by manufacturer, agreeing to repair or replace water heater units that fail in materials or workmanship within the specified warranty period. Failures include, but are not limited to, controls, tanks, and coils. This warranty shall be in addition to, and not a limitation of, other rights the Owner may have against the Contractor under the Contract Documents.
1. Commercial Electric Water Heaters:

a. Tank: Three years
b. Controls and Other Components: One year

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Commercial Electric Water Heaters:

a. A.O. Smith Water Products Co. Div.; A.O. Smith Corp.
b. Bradford-White Corp.
c. Lochinvar Water Heater Corp.
d. Rheem Mfg.
e. Ruud Mfg. Div of Rheem Mfg.
f. State Industries, Inc.

2. Thermal Expansion Tanks

a. Armstrong Pumps, Inc.
b. Amtrol, Inc.
c. Bell & Gosset, ITT
d. Elbi
e. TACO, Inc.
f. Watts

g. Wessels Tank Co.

3. Vacuum Relief Valves

a. Apollo #37
b. Cash ACME #VR-801
c. Watts #N36
d. Wilkins #VR-10

2.2 ELECTRIC WATER HEATERS

A. Description: Automatic, commercial, electric; with vertical, 150-psig-rated storage tank, integral controls, drain valve, and relief valve.

B. Insulation: Fiberglass or polyurethane foam, surrounding tank.

C. Jacket: Steel, with baked-on enamel finish.

D. Tank: Glass-lined steel with anode rods and drain valve.

E. Heating Elements: Screw-in or flanged bolt-in immersion type, in multiples as described on the drawings.

F. Controls: Adjustable surface mounted thermostats.

G. Safety Controls: Automatic, high-temperature-limit cutoff.

H. Temperature and Pressure Relief Valve: Lead free brass body meeting ANSI Z21.22.

2.3 THERMAL EXPANSION TANKS

A. Thermal Expansion Tanks: Provide size and number as indicated; construct of welded carbon steel listed for 150 psig working pressure, 200 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a FDA approved butyl rubber diaphragm securely sealed into tank. Provide taps for pressure gauge and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base.

2.4 VACUUM RELIEF VALVES

A. Lead free brass body meeting ANSI Z21.22 with silicon disc. Valve shall open at 0.5 inches HG vacuum and be rated for 200 psig working pressure and 250 F operating temperature.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. General: Install water heaters on concrete equipment bases. Set and connect units in accordance with manufacturer's written instructions. Install units plumb and level, firmly anchored

in locations indicated, and maintain manufacturer's recommended clearances. Orient so controls and devices needing servicing are accessible.

C. Install thermometers on water heater outlet piping. Thermometers and their installation requirements, are specified in Division 22 Section "Meters and Gauges for Plumbing Piping."

D. Install temperature and pressure relief valve furnished with water heater. The temperature shall be normally set to relieve at 210F and the pressure relief shall be equal to the tank pressure rating. Install line size relief valve discharge line to discharge to an approved receptor with air gap.

E. Vacuum Relief Valve: Install in cold water supply to each water heater downstream of the shutoff and check valves.

3.2 CONCRETE EQUIPMENT BASES

A. Construct concrete equipment bases in accordance with Division 22 Section "Common Work Results for Plumbing" for concrete and setting of equipment.

3.3 EXPANSION TANK INSTALLATION

A. Install in-line expansion tanks in the vertical position. Install in-line expansion tank in the horizontal position when allowed by manufacturer and provided with required supports.

B. Install stand mounted expansion tanks on concrete equipment bases.

C. Charge expansion tank bladder with air to a pressure equal to the domestic water static pressure.

3.4 CONNECTIONS

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

1. Install piping adjacent to equipment arranged to allow servicing and maintenance.
2. Connect hot and cold water piping to units with shutoff valves and unions. Connect hot water circulating piping to unit with shutoff valve, check valve, and union. Extend relief valve discharge to closest floor drain.

    a. Where water heater piping connections are dissimilar metals, install dielectric waterway fittings or dielectric unions for joints 2" and smaller and install dielectric flanges for joints 2-1/2" and larger. Dielectric waterway fittings, unions and flanges are specified in Division 22 Section "Basic Piping Materials and Methods."
    b. Install vacuum relief valve in cold water inlet piping.

3. Install drain as indirect waste to spill into open drain or over floor drain.

    a. Install drain valve at low point in water piping, for water heaters not having tank drain.

4. Install heat traps at inlet and outlet of each water heater storage tank. Heat trap shall be made of elbows and piping. Heat trap shall turn down to 12" below the outlet or inlet, run 12" horizontal and turn up to the cold water to the heater or hot water from the heater.

Where multiple tanks are connected with a manifold, a single heat trap may be provided at the connection of the cold water supply to the cold water manifold together.

B. Electrical Connections:

1. Power wiring is specified in Division 26 Section "Common Work Results for Electrical"
2. Field-installed disconnects are specified in Division 26 Sections "Enclosed Switches and Circuit Breakers".
3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.5 FIELD QUALITY CONTROL

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide start-up service, and demonstrate operation of equipment as specified below.

1. Test and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment.

3.6 STARTUP

A. Perform the following before start-up final checks:

1. Fill water heaters with water.
2. Piping systems test complete.
3. Check for piping connections leaks.
4. Test operation of safety controls and devices.

B. Perform the following start-up procedures:

1. Energize circuits.
2. Adjust operating controls.
3. Adjust hot water outlet temperature setting.

3.7 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of two hours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time,

attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes plumbing fixtures and trim, fittings, and accessories, appliances, appurtenances, equipment, and supports associated with plumbing fixtures.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 7 Section "Joint Sealers," for materials and methods for sealing between plumbing fixtures and interior walls.
2. Division 22 Section "General Duty Valves for Plumbing Piping" for valves used as supply stops.

C. Products installed but not furnished under this Section include:

1. Owner-supplied fixtures, as indicated.
2. Accessories, appliances, appurtenances, and equipment specified in other Sections, requiring plumbing services or fixture-related devices, as indicated.

1.2 DEFINITIONS

A. Accessible: Describes a plumbing fixture, building, facility, or portion thereof that can be approached, entered, and used by physically handicapped people.

B. Accessory: Device that adds effectiveness, convenience, or improved appearance to a fixture but is not essential to its operation.

C. Appliance: Device or machine designed and intended to perform a specific function.

D. Appurtenance: Device or assembly designed to perform some useful function when attached to or used with a fixture.

E. Equipment: Device used with plumbing fixtures or plumbing systems to perform a certain function for plumbing fixtures but that is not part of the fixture.

F. Fitting: Fitting installed on or attached to a fixture to control the flow of water into or out of the fixture.

G. Fixture: Installed receptor connected to the water distribution system, that receives and makes available potable water and discharges the used liquid or liquid-borne wastes directly or indirectly into the drainage system. The term "Fixture" means the actual receptor, except when used in a general application where terms "Fixture" and "Plumbing Fixture" include associated trim, fittings, accessories, appliances, appurtenances, support, and equipment.

H. Roughing-In: Installation of piping and support for the fixture prior to the actual installation of the fixture.

I. Support: Device normally concealed in building construction, for supporting and securing plumbing fixtures to walls and structural members. Supports for urinals, lavatories, and sinks are made in types suitable for fixture construction and the mounting required. Categories of supports are:

1. Carrier: Floor-mounted support for wall-mounted water closet, and support fixed to wall construction for wall-hung fixture.
2. Chair Carrier: Support for wall-hung fixture, having steel pipe uprights that transfer weight to the floor.
3. Chair Carrier, Heavy Duty: Support for wall-hung fixture, having rectangular steel uprights that transfer weight to the floor.
4. Reinforcement: Wood blocking or steel plate built into wall construction, for securing fixture to wall.

J. Trim: Hardware and miscellaneous parts, specific to a fixture and normally supplied with it required to complete fixture assembly and installation.

K. Lead Free: Refers to the wetted surface of pipe, fittings and fixtures in potable water systems that have a weighted average lead content ≤0.25% per Safe Drinking Water Act as amended January 4th 2011 Section 1417.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product data for each type of plumbing fixture specified, including fixture and trim, fittings, accessories, appliances, appurtenances, equipment, supports, construction details, dimensions of components, and finishes.
2. Wiring diagrams for field-installed wiring of electrically operated units.
3. Maintenance data for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 22 Section "General Plumbing Requirements."

B. Submit third party certification that faucets and trim for domestic water distribution for drinking or cooking comply with NSF 61 Annex G and / or NSF 372. The following faucets and trim need not comply:

1. Electronic faucets
2. Service sink faucets
3. Flush valves

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with requirements of ANSI Standard A117.1, "Buildings and Facilities -- Providing Accessibility and Usability for Physically Handicapped People," Public Law 90-480, "Architectural Barriers Act, 1968," with respect to plumbing fixtures for the physically handicapped and "Americans with Disabilities Act Accessibility Guidelines for Buildings 1991" with respect to plumbing fixtures for the physically handicapped.

B. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.

1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

C. Comply with NSF 61 Annex G and / or NSF 372 for wetted surfaces of faucets and trim containing no more than 0.25% lead by weight for domestic water distribution for drinking or cooking.

D. Design Concept: The drawings indicate types of plumbing fixtures and are based on the specific descriptions, manufacturers, models, and numbers indicated. Plumbing fixtures having equal performance characteristics by other manufacturers may be considered provided that deviations in dimensions, operation, color or finish, or other characteristics are minor and do not change the design concept or intended performance as judged by the Architect. Burden of proof for equality of plumbing fixtures is on the proposer.

1.5 SPARE PARTS

A. Deliver spare parts to Owner. Furnish spare parts described below matching products installed, packaged with protective covering for storage, and identified with labels clearly describing contents.

B. Faucet Washers and O-rings: Furnish quantity of identical units not less than 10 percent of amount of each installed.

C. Flushometer Repair Kits: Furnish quantity of identical units not less than 10 percent of amount of each flushometer installed.

D. Provide individual metal boxes or a hinged-top wood or metal box having separate compartments for each type and size of above extra materials.

E. Toilet Seats: Furnish quantity of identical units not less than 5 percent of amount of each type toilet seat installed.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products in each category, by one of the following listed for that category:

1. Water Closets:

    a. American Standard, Inc.
    b. Kohler Co.
    c. TOTO KIKI USA, Inc.

2. Urinals:

    a. American Standard, Inc.
    b. Kohler Co.
    c. TOTO KIKI USA, Inc.

3. Lavatories:

a. American Standard, Inc.
b. Kohler Co.
c. TOTO KIKI USA, Inc.

4. Sinks:
   a. Elkay Manufacturing Co.
   b. Just Manufacturing Co.
5. Mop Basins:
   a. Fiat Products.
   b. Florestone Products Co., Inc.
   c. Stern-Williams Co., Inc.
6. Water Coolers:
   a. Elkay Manufacturing Co.
   b. Halsey Taylor; A Household International Co.
   c. Haws Drinking Faucet Co.
   d. Oasis

7. Outlet Boxes:

   a. Guy Gray Manufacturing Co., Inc.
   b. Symmons Industries, Inc.
   c. Oatey Co.
8. Toilet Seats:

   a. Bemis Mfg. Co.
   b. Beneke Div.; Sanderson Plumbing Products, Inc.
   c. Church Seat Co.
   d. Forbes-Wright Industries, Inc.: Church Products
   e. Olsonite Corp.
9. Flushometers(turbine operated or 8-10-year battery life):

   a. Moen Commercial.
   b. Sloan Valve Co. (no photovoltaic)
   c. TOTO KIKI USA, Inc.
   d. Zurn Industries, Inc.; Flush Valve Operations.
10. Commercial/Industrial Cast-Brass Faucets:
    a. Chicago Faucet Co.
    b. Delta-Commercial
    c. Fisher Manufacturing Co.
    d. Kohler Co.
    e. Lawler
    f. Speakman Co.
    g. T & S Brass and Bronze Works, Inc.

11. Sensor-Operated Faucets and Devices (turbine operated or 8-10-year battery life):
    a. Moen Commercial.
    b. Sloan. (no photovoltaic)
    c. TOTO KIKI USA, Inc.
    d. Zurn Industries, LTD.

12. Stop Valves & Supplies:

    a. Brass Craft Subsidiary; Masco Co.
    b. Engineered Brass Company
    c. McGuire Manufacturing Co., Inc.
    d. PROFLO

e. Watts Brass and Tubular
f. Zurn Industries

13. P-traps, Drains & Miscellaneous Fittings:

a. Brass Craft Subsidiary; Masco Co.
b. Dearborn Brass
c. Engineered Brass Company
d. McGuire Manufacturing Co., Inc.
e. PROFLO
f. Watts Brass and Tubular
g. Zurn Industries

14. Supports:

a. Josam Co.
b. Smith (Jay R.) Mfg. Co.
c. Wade Div.; Tyler Pipe.
d. Watts Drainage Products
e. Zurn Industries, Inc.; Hydromechanics Div.
f. Mifab Manufacturing, Inc.

15. Insulation Kits

a. Brocar
b. McGuire
c. Plumberex
d. PROFLO
e. Trap-Wrap
f. Truebro, Inc.

2.2 PLUMBING FIXTURES, GENERAL

A. Provide plumbing fixtures and trim, fittings, other components, and supports as specified on the drawings and below:

2.3 FAUCETS

A. Faucets General: As described on the drawings.

1. All electronically controlled faucets shall be installed with check valves to prevent water mixing temperature crossover (hot-cold).

2.4 STOP VALVES & SUPPLIES

A. Supplies General: As described on the drawings.

1. Exposed piping and parts shall be polished chrome plated.

2.5 P-TRAPS, DRAINS AND MISCELLLANEOUS FITTINGS:

A. Fittings General: As described on the drawings, except as listed below.

1. Exposed piping and fittings shall be polished chrome plated.
2. Fittings installed concealed inside a plumbing fixture or within wall construction may be without chrome plate finish.
3. Fitting and faucet bodies for domestic water distribution shall be of lead free brass or lead free cast bronze.

B. Sink Continuous Wastes: Polished chrome-plated, tubular brass, 1-1/2 inches, 17 gauge, with brass nuts on slip inlets, and of configurations indicated.

C. Escutcheons: Wall flange with set screw.

D. Deep Pattern Escutcheons: Wall flange with set screw or sheet steel wall flange with friction clips, of depth adequate to conceal protruding roughing-in fittings.

2.6 FLUSHOMETERS

A. Provide flushometers compatible with fixtures, with features and of consumption indicated as described on the drawings.

1. Exposed metal parts shall be polished chrome plated.

2.7 TOILET SEATS

A. General: As described on the drawings.

2.8 PLUMBING FIXTURE SUPPORTS

A. Supports: ASME A112.6.1M, categories and types as required for wall-hanging fixtures specified, and wall reinforcement.

B. Support categories are:

1. Carriers: Supports for wall-hanging water closets and fixtures supported from wall construction. Water closet carriers shall have an additional faceplate and coupling when used for wide pipe spaces. Provide tiling frame or setting gauge with carriers for wall-hanging water closets.
2. Chair Carriers: Supports with steel pipe uprights for wall-hanging fixtures. Urinal chair carriers shall have bearing plates.
3. Chair Carriers, Heavy Duty: Supports with rectangular steel uprights for wall-hanging fixtures.
4. Reinforcement: 2-inch by 4-inch wood blocking between studs or 1/4-inch by 6-inch steel plates attached to studs, in wall construction, to secure floor-mounted and special fixtures to wall.

C. Support Types: Provide support of category specified, of type having features required to match fixture.

D. Provide supports specified as part of fixture description, in lieu of category and type requirements above.

2.9 INSULATION KITS

A. Insulation kits for lavatory and sink waste and supplies of vinyl plastic with reusable fasteners and openings for access to supply stop handles.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install fixtures, trim and supports in accordance with manufacturer's installation instructions.

3.2 APPLICATION

A. Install plumbing fixtures and specified components, in accordance with designations and locations indicated on Drawings.

B. Install supports for plumbing fixtures in accordance with categories indicated, and of type required:

1. Carriers for following fixtures:

a. Wall-hanging water closets.
b. Wall hanging lavatories
c. Wall hanging electric water coolers.
d. Wall-hanging fixtures supported from wall construction.

2. Chair carriers for the following fixtures:

a. Wall-hanging urinals.
b. Wall-hanging lavatories and sinks.
c. Wall-hanging electric water coolers.

3. Heavy-duty chair carriers for the following fixtures:

a. Accessible lavatories.
b. Fixtures where specified.

4. Reinforcement for the following fixtures:
a. Wall mounted and mop sink faucets.
b. Urinal flush valve solid pipe ring supports.

3.3 INSTALLATION OF PLUMBING FIXTURES

A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers' written installation instructions, roughing-in drawings, and referenced standards.

B. Install wall-hanging, back-outlet water closets with support manufacturer's tiling frame or setting gauge.

C. Install wall-hanging, back-outlet urinals with gasket seals.

D. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.

E. Fasten floor-mounted fixtures and special fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.

F. Fasten wall-mounted fittings to reinforcement built into walls.

G. Fasten counter-mounting-type plumbing fixtures to casework.

H. Secure supplies behind wall or within wall pipe space, providing rigid installation.

I. Set mop basins in leveling bed of cement grout.

J. Install stop valve in an accessible location in each water supply to each fixture.

K. Install trap on fixture outlet except for fixtures having integral trap.

L. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons where required to conceal protruding pipe fittings.

M. Seal fixtures to walls, floors, and counters using a sanitary-type, one-part, mildew-resistant, silicone sealant in accordance with sealing requirements specified in Division 7 Section "Joint Sealers." Match sealant color to fixture color.

N. Install insulation kits on ADA compliant sink and lavatory waste, continuous wastes, hot and cold water supplies where indicated on the drawings and as required by the ADA.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other sections of Division 22. The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections of Division 22.

2. Install piping connections indicated between appliances and equipment specified in other sections, direct connected to plumbing piping systems.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.6 ADJUSTING AND CLEANING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust disposers, hot water dispensers, and controls. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at drinking fountains, electric water coolers, and faucets, shower valves, and flushometers having controls, to provide proper flow and stream.

D. Replace washers of leaking and dripping faucets and stops.

E. Clean fixtures, fittings, and spout and drain strainers with manufacturers' recommended cleaning methods and materials.

F. Adjust faucet wrist blade handles perpendicular to the spout while in the closed position.

G. Review the data in Operating and Maintenance Manuals. Refer to Division 1 Section "Project Closeout."

H. Set each shower valve temperature limit stop to 110ºF. Perform work after the shower head is installed and the domestic water heater is in operation. Allow the hot water to run for 5 minutes minimum or until temperature reaches equilibrium. Allow cold to run for 5 minutes minimum or until temperature reaches equilibrium. Provide the architect a report and schedule indicating the hot, cold and mixed maximum water temperature at each shower.

3.7 FIXTURE SCHEDULE

A. Provide plumbing fixtures as specified on the drawings.

B. Install rough-in for plumbing fixtures as scheduled on the drawings.

3.8 MOUNTING HEIGHTS SCHEDULE:

A. Refer to the architectural drawings for plumbing fixture mounting heights. Unless indicated otherwise, install plumbing fixtures with the mounting heights as listed below with final approval by the Architect:

FIXTURE	MOUNTING HEIGHT
Ice Maker Outlet Boxes	24" floor to center of box
Janitor's Sink Faucet Fittings	42" floor to centerline
Hose Bibbs	36" AFF to centerline
Non Freeze Wall Hydrant	18" AFG to centerline

END OF SECTION

SECTION 227000 - NATURAL GAS SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes distribution piping systems for natural gas, liquid petroleum-gas and manufactured gas within the building and extending from the point of delivery to the connections with gas utilization devices. Piping materials and equipment specified in this Section include:

1. Pipes, fittings, and specialties.
2. Special duty valves.
3. Pressure regulators.

B. Contractors Option:

1. The Division 22 contractor may provide mechanically joined joints for natural gas systems to connect couplings, fittings, valves and related components as an option in lieu of, in whole or in part, welded, threaded or flanged piping methods. Mechanically joined natural gas systems where used shall be provided in compliance with specification Section 227011 "Mechanically Joined Natural Gas Systems".

C. This Section does not apply to liquid petroleum piping; industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen and nitrogen; gas piping, meters, gas pressure regulators and other appurtenances used by the serving gas supplier in distribution of gas.

D. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "General plumbing Requirements," for trenching, excavation, backfill and compaction materials and methods for underground piping installations.
2. Division 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls.
3. Division 9 Section "Painting," for materials and methods for painting pipe.
4. Division 12 Section "Laboratory Casework and Fixtures," for laboratory trim installed in the casework.
5. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations and wall and floor penetrations.
6. Division 22 Section "Basic Piping Material and Methods," for materials and methods for strainers, unions, dielectric flanges and mechanical sleeve seals.
7. Division 22 Section "Hangers and Supports for Plumbing Piping," for materials and methods for hanging and supporting gas distribution piping.
8. Division 26 Section "Common Work Results for Electrical" required electrical devices.

E. Gas pressures for systems specified in this Section are limited to 2 psig.

F. Products furnished under this Section include gas meters and gas service piping, which will be provided by the utility company to the site. The following is the name and address of the utility company:

Company: __Spire_____

Telephone number: (816) 360-5775

1.2 DEFINITIONS

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

B. Gas Distribution Piping: A pipe within the building which conveys gas from the point of delivery to the points of usage.

C. Gas Service Piping: The pipe from the gas main or other source of supply including the meter, regulating valve, or service valve to the gas distribution system of the building served.

D. Point of Delivery: The outlet of the service meter assembly, or the outlet of the service regulator (service shutoff valve when no meter is provided).

1.3 SUBMITTALS

A. Product data for each gas piping specialty and special duty valves. Include rated capacities of selected models, furnished specialties and accessories, and installation instructions.

B. Shop drawings detailing dimensions, required clearances, for connections to gas meter.

C. Coordination drawings for gas distribution piping systems in accordance with Division 22 Section "General Plumbing Requirements."

D. Maintenance data for gas specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 1 and Division 22 Section "General Plumbing Requirements."

E. Welders' qualification certificates, certifying that welders comply with the quality requirements specified under "Quality Assurance" below.

F. Test reports specified in Part 3 below.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Installation and replacement of gas piping, gas utilization equipment or accessories, and repair and servicing of equipment shall be performed only by a qualified installer. The term qualified is defined as experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with precautions required, and has complied with the requirements of the authority having jurisdiction. Upon request, submit evidence of such qualifications to the Architect.

B. Qualifications for Welding Processes and Operators: Comply with the requirements of ASME Boiler and Pressure Vessel Code, "Welding and Brazing Qualification."

C. Regulatory Requirements: Comply with the requirements of the following codes:

1. NFPA 54 - National Fuel Gas Code, for gas piping materials and components, gas piping installation and inspections, testing, and purging of gas piping systems.

D. Local Gas Utility Requirements: Comply with local gas utility installation rules and regulations.

E. Pipe, pipe fittings and pipe specialties shall be manufactured in plants located in the United States or certified to meet the specified ASTM and ANSI standards.

1.5 SPARE PARTS

A. Valve Wrenches: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide gas piping system products from one of the following:

1. Gas Ball Valves – 2" and Smaller:

   a. Apollo Valves # 77F-1XX-01
   b. Hammond Valve # 8901
   c. Milwaukee Valve # BA-475B
   d. Nibco Inc. # T-FP 600A
   e. Watts # FBV-3C

2. Gas Cocks – 2" and Smaller:

   a. Homestead # 601
   b. Milliken #200M
   c. RM Energy Systems # D125

3. Gas Cocks – 2-1/2" and Larger:

   a. Homestead # 602
   b. Milliken #200MF
   c. RM Energy Systems "Hercules" # D126

4. CSA Listed Gas Pressure Regulators

   a. Karl Dungs, Inc.
   b. Maxitrol
   c. Pietro-Fiorentini

5. Insect Screens

   a. Northtown Pipe Protection Products "BUGSCRN Series"

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3, Article "PIPE APPLICATIONS" for identification of systems where the specified pipe and fitting materials listed below are used.

B. Steel Pipe: ASTM A 53, Grade B, Schedule 40, (Type E electric-resistance welded or Type S seamless, black steel pipe, beveled ends).

2.3 FITTINGS

A. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

B. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.

1. 1-1/4" and smaller shall be socket type
2. 1-1/2" and larger shall be butt weld type.

C. Forged Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, butt weld ends, standard pattern with bolts, nuts and gaskets of material group 1.1.

D. Insect screens: Black steel body with 20 mesh stainless steel screen and MNPT end.

2.4 JOINING MATERIALS

A. Joint Compound: Suitable for the gas being handled.

B. Gasket Material: Thickness, material, and type suitable for gas to be handled, and for design temperatures and pressures.

2.5 PIPING SPECIALTIES

A. Protective Coating: When piping will be in contact with material or atmosphere exerting a corrosive action, pipe and fittings shall be factory-coated with polyethylene tape, having the following properties:

1. overall thickness; 20 mils.
2. synthetic adhesive.
3. water vapor transmission rate, gallons per 100 square inch: 0.10 or less.
4. water absorption, percent: 0.02 or less.

B. Prime pipe and fittings with a compatible primer prior to application of tape.

C. Strike Plates: 16 gauge carbon steel, tested and listed by CSA International.

D. In wall Strike Protection Hose: UL listed spiral wound interlocking galvanized steel reduced wall flexible conduit.

E. Non metallic Water Tight Conduit: Schedule 80 rigid PVC, UL 651, with fittings to match to conduit type and material.

F. Multiple Port Manifolds: ANSI LC1b, plastic coated malleable iron, of the same manufacturer of the corrugated stainless steel tubing, tested and listed by CSA International.

2.6 VALVES

A. Gas Ball Valves – 2" and Smaller: Full port brass body with brass ball, PTFE seats, threaded ends 150psi steam, 600 WOG, UL listed for natural gas service.

B. Gas Cocks 2 Inch and Smaller: 175 psi, lubricated plug type, ASTM A126 Grade B semi-steel body, brass or semi-steel plug with full area rectangular port, straightaway pattern, square head, threaded ends.

C. Gas Cocks 2-1/2 Inch and Larger: 175 psi, lubricated plug type, ASTM A126 Grade B semi-steel body and plug with full area rectangular port, straightaway pattern, single gland, wrench operated, flanged ends.

D. Solenoid Valves: As specified on the drawings.

E. Gas Line Pressure Regulators: Single stage, steel jacketed, corrosion-resistant gas pressure regulators; with atmospheric vent, elevation compensator; internal relief vent, vent limiter for indoor installation, with threaded ends for 2 inch and smaller, flanged ends for 2-1/2 inch and larger; for inlet and outlet gas pressures, specific gravity, and volume flow as indicated on the drawings.

1. CSA listed for 2 PSI gas systems

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pipe, fittings, valves and specialties in accordance with manufacturer's installation instructions.

3.2 PREPARATION

A. Precautions: Before turning off the gas to the premises, or section of piping, turn off all equipment valves. Perform a leakage test as specified in "FIELD QUALITY CONTROL" below, to determine that all equipment is turned off in the piping section to be affected.

B. Conform with the requirements in NFPA 54, for the prevention of accidental ignition.

3.3 PREPARATION FOUNDATION FOR UNDERGROUND GAS SERVICE PIPING

A. Pipe Beds for Pre-sleeved Vent Capable Semi-rigid Corrugated Stainless Steel Tubing, PE Pipe and PVC Pipe Conduit: Support pipe in trench with sand bags level and true to prevent sand, gravel or debris from interfering with the solvent cement or fusion process. After pressure testing is complete, gradually install bedding to maintain continuous pipe slope and prevent pipe deflection and then install subbase. Refer to Division 22 Section "General Plumbing Requirements" for bedding and subbase materials, excavation, trenching, backfill and compaction

requirements and refer to ASTM D2321 "Underground Installation of Thermoplastic Pipe for Sewers and Gravity-flow Applications" for additional requirements.

3.4 PIPE APPLICATIONS

A. Install steel pipe with threaded joints and fittings for low pressure gas piping 2 inch and smaller.

B. Install steel piping with welded joints for low pressure gas piping 2-1/2 inch and larger and for all sizes of elevated pressure gas piping.

C. Install PE plastic pipe with fusion bond plastic fittings below grade outside the building slab.

3.5 PIPING INSTALLATION

A. General: Conform to the requirements of NFPA 54 - National Fuel Gas Code.

B. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Design locations and arrangements of piping take into consideration pipe sizing, flow direction, slope of pipe, expansion, and other design considerations. So far as practical, install piping as indicated.

C. Concealed Locations: As specified below:

1. Inaccessible Above-Ceiling Locations: Install concealed gas piping in inaccessible above-ceiling spaces without valves or unions.
2. Accessible Above-Ceiling Locations: Gas piping may be installed in accessible above-ceiling spaces (subject to the approval of the authority having jurisdiction), whether or not such spaces are used as a plenum. Valves and unions shall not be located in such spaces used as a plenum.
3. In Floors: Install concealed gas piping in concrete floor slabs in an air-tight conduit constructed of Schedule 40 PVC with socket weld joints two pipe sizes larger than the gas pipe served. Extend conduit a minimum of 12" above finish floor and cap air tight at both ends. Vent conduit to the outside with a minimum 2" pipe and terminate with a screened vent cap.
4. Concrete or Masonry Walls: Do not install gas piping in masonry or concrete walls.
5. Prohibited Locations: Do not install gas piping in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumbwaiter or elevator shaft. This does not apply to accessible above-ceiling space specified above.

D. Fire Barrier Penetrations: Where pipes pass though fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity. Refer to Division 22 Section "Common Work Results for Plumbing" for special sealers and materials.

E. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of No-Fire Rated Walls and Concrete Slab on Grade Penetrations: Provide sleeves and seal pipes that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 22 Section "Basic Piping Materials and Methods" for special sealers and materials.

F. Exterior Wall Penetrations: Seal pipe penetrations through exterior wall constructions with sleeves, packing, and sealant. Refer to Division 22 Section "Common Work Results for Plumbing" for additional information.

G. Dirt legs and Sediment Traps: Install a dirt leg at points where condensate and impurities may collect, at the outlet of the gas meter, as close to the inlet of each gas appliance or equipment as possible, and in a location readily accessible to permit cleaning and emptying.

1. Construct dirt legs and sediment traps using a tee fitting with the bottom outlet plugged or capped. Provide a 3" length of pipe and screwed cap for the dirt leg. Use line size pipe for dirt leg, refer to the drawings for sizes. Enter the tee with flow from the top and exit the tee from the side outlet. Install the dirt leg a minimum of 3-1/2" above the roof or floor readily accessible to permit cleaning and emptying.
2. Install line size gas cock, union and dirt leg at each equipment connection; refer to the drawings for sizes. Provide reducers at the equipment connection as required. Unions are specified in Division 22 section "Basic Piping Materials and Methods".

H. Use fittings for all changes in direction and all branch connections.

I. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

J. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

K. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

L. Install horizontal piping as high as possible allowing for specified slope and coordination with other components. Install vertical piping tight to columns or walls. Allow sufficient space above removable ceiling panels to allow for panel removal.

M. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

N. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

O. Connect branch outlet pipes from the top or sides of horizontal lines, not from the bottom.

P. Install unions in pipes 2 inch and smaller, adjacent to each valve, and elsewhere as indicated. Unions are not required on flanged devices. Unions are specified in Section "Basic Piping Materials and Methods".

Q. Joints Containing Dissimilar Metals: Provide dielectric unions for 2" and smaller and dielectric flanges for piping 2-1/2" and larger. Dielectric unions and flanges are specified in Section "Basic Piping Materials and Methods".

R. Install flanges on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

S. Paint Exposed Outdoor Gas Piping: Cleaning and painting of exposed outdoor gas piping is specified in Division 9 Section "Painting".

1. Final color per the architect.

3.6 HANGERS AND SUPPORTS

A. General: Hanger, support, and anchor components and installation procedures conforming to MSS SP-58 and SP-69 are specified in Division 22 Section "Hangers and Supports for Plumbing Piping". Conform to the table below for maximum spacing of supports.

B. Pipe Attachments: Install the following:

1. Adjustable clevis hangers, MSS SP-69 Type 1, for steel pipe 2-1/2" and larger for individual horizontal runs.
2. Riser clamps, MSS SP-69 Type 8, for individual vertical runs.
3. Extension split ring pipe clamp, MSS SP-69 Type 12, for individual exposed runs on walls.
4. Engineered strut support system may be provided, at the contractor's option, in lieu of individual hangers for horizontal pipes as specified in Division 22 "Hangers and Supports for Plumbing Piping". Provide two piece straps for uninsulated pipe secured to the bare pipe and provide plastic galvanic isolators for bare copper tube.
5. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

SIZE (NPS)	SPACING IN FEET	MIN. ROD SIZE IN INCHES
1/2" to 1"	7	3/8
1-1/4"	8	3/8
1-1/2"	9	3/8
2"	10	3/8
2-1/2"	11	1/2
3"	12	1/2
4"	14	5/8
6"	16	3/4

C. Support vertical piping at every floor.

D. Support gas piping within 12" of each elbow or tee and for gas piping 2-1/2" and larger at each valve or pressure regulator.

E. Support gas piping located on roof with pre-engineered roof supports, pre-engineered roof supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping". Conform to the table above for maximum spacing of supports. Support pipe at a minimum 7" above the roof.

3.7 PIPE JOINT CONSTRUCTION

A. Welded Joints: Comply with the requirements in ASME Boiler and Pressure Vessel Code, Section IX.

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint. Refer to NFPA 54, for guide for number and length of threads for field threading steel pipe.

2. Align threads at point of assembly.
3. Apply thread compound for use with gas systems to the external pipe threads. Pipe thread tape is not accepted.
4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.
5. Damaged Threads: Do not use pipe with threads which are corroded, or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

D. Fusion Welded: Joints shall be made by a qualified and approved operator in accordance with Title 49, CFR, Part 192.283 and be made in accordance with pipe manufacturer's recommendations.

3.8 VALVE APPLICATIONS

A. General: The Drawings indicate valve types, locations, and arrangements.

B. Shut-off duty: Use gas cocks and ball valves specified in Part 2 above.

3.9 VALVE INSTALLATIONS

A. Install valves in accessible locations, protected from physical damage. Tag valves with a metal tag attached with a metal chain indicating the piping systems supplied.

B. Install laboratory gas cocks with inlet sized all thread shank and backing nut. Tighten backing nut to secured gas turret or gas cock to casework or wall. For wall mounted laboratory gas cocks, provide wood block backing in wall.

C. Install line size gas ball valve at the outlet of the gas meter set or gas riser and install a line size union downstream of the gas cock outside of the building.

D. Installation of Gas Pressure Regulators:

1. Install a gas cock or ball valve 10 pipe diameters upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve is not required at the second regulator.
2. Install line pressure regulators a minimum of 10 pipe diameters upstream of each atmospheric or power burner equipment connection.
3. Install line pressure regulators a minimum of 10'-0" upstream of each condensing boiler or water heater connection.
4. Install gas pressure regulator relief devices so they can be readily operated to determine if the valve is free; so they can be tested to determine the pressure at which they will operate; and examined for leakage when in the closed position.
5. Install gas pressure regulators with listed vent limiters indoors where allowed by the AHJ. Install with regulator dome vertically upright and level.
6. Install gas pressure regulators located outside the building with the relief port facing down to prevent the entry of moisture with the relief port a minimum of 18" above the roof or finish grade. Remove vent limiter and provide with line size (same size as gas vent relief port) insect screen or gas relief vent and 1" long schedule 40 black steel nipple.

a. Where manufacturer does not allow the gas pressure regulator to be installed upside down, use a different regulator from the acceptable manufacturer list.

3.10 TERMINAL EQUIPMENT CONNECTIONS

A. Install line size gas cock upstream and within 6 feet of gas appliance. Install a line size union or flanged connection downstream from the gas cock to permit removal of controls. Install reducer at the gas appliance connection, if required.

3.11 ELECTRICAL BONDING AND GROUNDING

A. Install above ground portions of gas piping systems, upstream from equipment shutoff valves electrically continuous and bonded to a grounding electrode in accordance with NFPA 70 - "National Electrical Code."

B. Do not use gas piping as a grounding electrode.

C. Conform to NFPA 70 - "National Electrical Code," for electrical connections between wiring and electrically operated control devices.

3.12 FIELD QUALITY CONTROL

A. Piping Tests: Inspect, test, and purge natural gas systems in accordance with NFPA 54, and local utility requirements.

END OF SECTION

SECTION 227010 - MECHANICALLY JOINED NATURAL GAS PIPING SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes mechanically joined fittings and valves for distribution piping systems for natural gas within the building and extending from the point of delivery to the connections with gas utilization devices. Piping materials and equipment specified in this Section include:

1. Fittings.

B. This Section does not apply to liquid petroleum piping; industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen and nitrogen; gas piping, meters, gas pressure regulators and other appurtenances used by the serving gas supplier in distribution of gas.

C. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 22 Section "Natural Gas Systems," for valves, hangers, natural gas systems and installation requirements.

D. Gas pressures for systems specified in this Section are limited to 2 psig.

1.2 SUBMITTALS

A. Product data for each mechanically joined gas pipe fitting. Include rated capacities of selected models, furnished specialties and accessories, and installation instructions.

B. Maintenance data for mechanically joined gas pipe fittings, for inclusion in operating and maintenance manual specified in Division 1 and Division 22 Section "General Plumbing Requirements."

C. Installer qualification certificates, certifying that installers comply with the quality requirements specified under "Quality Assurance" below.

D. Test reports specified in Part 3 below.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Installation of mechanically joined fittings shall be performed only by a qualified installer. The term qualified is defined as experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with precautions required, and has complied with the requirements of the authority having jurisdiction. Upon request, submit evidence of such qualifications to the Architect.

B. Local Gas Utility Requirements: Installation of mechanically joined fittings shall comply with local gas utility installation rules and regulations.

C. Mechanically joined fittings shall be manufactured in plants located in the United States or certified to meet the specified ASTM and ANSI standards.

D. Obtain training from the mechanically joined fittings manufacturer for all workers that will be installing or handling the mechanically joined fittings.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide gas piping system products from one of the following:

1. Mechanically Joined Fittings:

a. Viega "Mega-Press G Fittings"
b. Apollo "PowerPress"

2.2 FITTINGS

A. Mechanically Joined Fittings: ½ inch through 4 inch meeting ANSI LC4-2012 /CSA 6.32-2012 2nd Edition with zinc/nickel coating, HNBR sealing element, 420 stainless steel grip ring, 304 stainless steel separator ring, and Smart Connect (SC) Feature that allows the joint to leak if not properly sealed. Fittings shall be for use with IPS schedule 10 thru schedule 40 carbon steel, or galvanized pipe meeting ASTM A53. Fittings shall have temperature and pressure rating of -40F to 180F at a maximum operating pressure of 125 psi.

2.3 VALVES

A. Mechanically Joined Gas Ball Valves: ½ inch through 2 inch carbon steel body meeting ASTM A216 with full port 316 stainless steel ball meeting ASTM A276, blowout-proof stem, with replaceable "Teflon" or "PTFE" seats and seals, solder ends and vinyl-covered steel handle. Provide with mechanically joined ends meeting ASTM LC4 with HNBR O-ring.

1. Apollo "PowerPress" # 89FHV4 series

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Install fittings and valves in accordance with manufacturer's installation instructions.

3.2 PREPARATION

A. Precautions: Before turning off the gas to the premises, or section of piping, turn off all equipment valves. Perform a leakage test as specified in "FIELD QUALITY CONTROL" below, to determine that all equipment is turned off in the piping section to be affected.

B. Conform with the requirements in NFPA 54, for the prevention of accidental ignition.

3.3 PIPE APPLICATIONS

A. Install above floor steel pipe with mechanically joined fittings for pipe 1/2 inch and larger up to 4".

3.4 PIPING INSTALLATION

A. Piping Installation requirements are specified in Division 22 Section "Natural Gas Systems".

3.5 PIPE JOINT CONSTRUCTION

A. Joint materials and installation requirements are specified in Division 22 Section "Natural Gas Systems".

B. Joints for Mechanically Joined Fittings: Comply with the manufacturer's installation instructions and Requirements:

1. Cut pipe ends at right angle (square) to the pipe.
2. Ream pipe ends with chamfer.
3. Remove paint, lacquer, grease, oil or dirt from the pipe end with an abrasive cloth, or with the "Ridgid MegaPress" pipe end prep tool.
4. Visually examine the fitting sealing element to ensure there is no damage.
5. Utilize a "Viega MegaPress Insertion Depth Inspection Gauge" to mark the pipe wall, with a felt tip pen, at the appropriate location, or insert the pipe fully into the fitting and mark the pipe wall at the face of the fitting.
6. Verify the pipe is fully inserted into the fitting prior to pressing the joint.
7. Install mechanically joined fittings using "Ridgid" MegaPress Tools.

3.6 VALVE APPLICATIONS

A. Valves are specified in Division 22 Section "Natural Gas Systems".

B. Valves can be installed with screwed joints for 2" and smaller and flanged joints for 2-1/2" and larger. Or, valves can be provided with mechanically joined fitting adapters and the joints installed as specified herein.

3.7 VALVE INSTALLATIONS

A. Valve installation requirements are specified in Division 22 Section "Natural Gas Systems".

3.8 FIELD QUALITY CONTROL

A. Field quality control requirements are specified in Division 22 Section "Natural Gas Systems".

B. Installing contractor shall schedule training session with the mechanically joined fittings manufacturer at project site for all workers that will be installing or handling mechanically joined fittings. Submit certification letter along with list of certified attendees to Architect within 30-days of mobilization. Include copy of certification letter with closeout documents. Mechanically joined

fittings manufacturer shall provide certification training to the contractor without cost and without additional cost to the Owner.

C. Piping Tests: Inspect, test, and purge natural gas systems in accordance with NFPA 54, and local utility requirements.

D. Manufacturer's Piping Test: Provide two-step test process as follows:

1. Pressurize the system between 0.5 psi and 45 psi with air or dry nitrogen.
2. If the system does not hold pressure, walk the system and check for un-pressed fittings.
3. If un-pressed fittings are found, ensure the pipe is fully inserted into the fitting and properly marked prior to pressing the joint.
4. If failed joints are fond, cut out the failed fitting and replace with new as specified herein.
5. After appropriate repairs have been made, test the system per local code, not to exceed 200 psig.

END OF SECTION 227010

SECTION 230010 - GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. This Division requires the furnishing and installing of complete functioning systems, and each element thereof, as specified or indicated on the Drawings and Specifications or reasonably inferred; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include materials, labor, supervision, supplies, equipment, transportation, and utilities.

B. Division 23 of the Specifications and Drawings numbered with prefixes M, MP or ME, or MEP generally describe these systems, but the scope of the Mechanical work includes all such work indicated in the Contract Documents: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.

C. The Drawings have been prepared diagrammatically intended to convey the scope of work, indicating the intended general arrangement of the equipment, fixtures, ductwork, piping, etc. without showing all the exact details as to elevations, offsets, control lines, and other installation requirements. The Contractor shall use the Drawings as a guide when laying out the work and shall verify that materials and equipment will fit into the designated spaces, and which, when installed per manufacturers requirements, will ensure a complete, coordinated, satisfactory and properly operating system.

1.2 QUALITY ASSURANCE

A. All work under this Division shall be executed in a thorough professional manner by competent and experienced workmen licensed to perform the Work specified.

B. All work shall be installed in strict conformance with manufacturers' requirements, recommendations, and installation instructions. Equipment and materials shall be installed in a neat and professional manner and shall be aligned, leveled, and adjusted for satisfactory operation.

C. Material and equipment shall be new, shall be of the best quality and design, shall be current model of the manufacturer, shall be free from defects and imperfections and shall have markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Material and equipment of the same type shall be made by the same manufacturer whenever practicable.

D. Unless specified otherwise, manufactured items shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this project.

1.3 CODES, REFERENCES AND STANDARDS

A. Execute Work in accordance with the National Fire Protection Association and all Local, State, and National codes, ordinances and regulations in force governing the particular class of Work

involved. Obtain timely inspections by the constituted authorities, and upon final completion of the Work obtain and deliver to the Owner executed final certificates of acceptance from the Authority Having Jurisdiction.

B. Any conflict between these Specifications and accompanying Drawings and the applicable Local, State and Federal codes, ordinances and regulations shall be reported to the Architect in sufficient time, prior to the opening of Bids, to prepare the Supplementary Drawings and Specification Addenda required to resolve the conflict.

C. The governing codes are minimum requirements. Where these Drawings and Specifications exceed the code requirements, these Drawings and Specification shall prevail.

D. All material, manufacturing methods, handling, dimensions, method or installation and test procedure shall conform to but not be limited to the following industry standards and codes:

IBC	International Building Code
IMC	International Mechanical Code
IPC	International Plumbing Code
IFC	International Fire Code
IFGC	International Fuel Gas Code
ADA	American Disabilities Act
ADC	Air Diffusion Council
AMCA	Air Movement and Control Association, Inc.
ANSI	American National Standards Institute
AHRI	Air Conditioning, Heating and Refrigeration Institute
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society of Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
CISPI	Cast Iron Soil Pipe Institute
ETL	Electrical Testing Laboratories
HI	Hydraulic Institute
MSS	Manufacturer's Standardization Society of the Valve and Fitting Industry
NBFU	National Board of Fire Underwriters
NEC	National Electrical Code
NFPA	National Fire Protection Association
NEMA	National Electrical Manufactures' Association
OSHA	Occupational Safety and Health Act
PDI	Plumbing and Drainage Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.
UL	Underwriter's Laboratories

E. Contractor shall comply with rules and regulations of public utilities and municipal departments affected by connections of services.

F. All mechanical work shall be performed in compliance with applicable safety regulations, including OSHA regulations. Safety lights, guards, shoring and warning signs required for the performance of the mechanical work shall be provided by the Contractor.

1.4 DEFINITIONS

A. General:

1. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation and similar operations."
2. Install: The term "install" is used to describe operations at the project site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
3. Provide: The term "provide" means "to furnish and install, complete and ready for the intended use. When 'furnish', 'install', 'perform', or 'provide' is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of Contractor, "provide" is implied.
4. Furnished by Owner or Furnished by Others: The item will be furnished by the Owner or Others. It is to be installed and connected under the requirements of this Division, complete and ready for operation, including items incidental to the Work, including services necessary for proper installation and operation. The installation shall be included under the guarantee required by this Division.
5. Engineer: Where referenced in this Division, "Engineer" is the Engineer of Record and the Design Professional for the Work under this Division, and is a Consultant to, and an authorized representative of, the Architect, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the "Architect".
6. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.
7. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other listed Manufacturers and models that meet the specified criteria.
8. Substitution: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor. Substitutions include Value Engineering proposals.

    a. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
    b. Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.

9. Value Engineering: A systematic method to improve the "value" of goods and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. The goal of VE is to achieve the desired function at the lowest overall cost consistent with required performance.

B. The terms "approved equal", "equivalent", or "equal" are used synonymously and shall mean "accepted by or acceptable to the Engineer as equivalent to the item or manufacturer specified". The term "approved" shall mean labeled, listed, or both, by an NRTL, and acceptable to the AHJ over this project.

1.5 COORDINATION

A. The Contractor shall visit the site and ascertain the conditions to be encountered while installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make due provision for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, incorrect or faulty installation of Work under this Division or for additional compensation for Work covered by this Division.

B. The Contractor shall refer to Drawings of the other disciplines and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. The Contractor shall make offsets required to clear equipment, beams and other structural members; and to facilitate concealing piping and ductwork in the manner anticipated in the design.

C. The Contractor shall confirm and coordinate the final location and routing of all mechanical, electrical, plumbing, fire protection, control and audio-visual systems with all architectural features, structural components, and other trades. The contractor shall locate equipment, components, ductwork, piping, conduit, and related accessories to maintain the desired ceiling heights as indicated on the architectural drawings. The contractor shall inform the architect of any areas where conflicts may prevent the indicated ceiling height from being maintained. The contractor shall not proceed with any installation in such areas until the architect has given written approval to proceed or has provided modified contract drawings or written instructions to resolve the apparent conflict.

D. The Contractor shall provide materials with trim which will fit properly the types of ceiling, wall, or floor finishes actually installed.

E. The Contractor shall maintain a foreman on the jobsite at all times to coordinate the work with other contractors and subcontractors so that various components of the mechanical systems will be installed at the proper time, will fit the available space, and will allow proper service access to the equipment. Carry on the Work in such a manner that the Work of the other contractors and trades will not be handicapped, hindered, or delayed at any time.

F. Work of this Division shall progress according to the "Construction Schedule" as established by the Prime Contractor and their subcontractors and as approved by the Architect. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule so as to ensure successful achievement of schedule dates.

1.6 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to the requirements of individual Sections. Additionally, prepare coordination drawings as required scope of installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one trade.

1. Information shall be project specific and drawn accurately to a scale large enough to resolve conflicts. Do not base coordination drawings on standard dimensional data.
2. Prepare floorplans, sections, elevations, and details as needed to adequately describe relationship of various systems and components.

3. Clearly indicate functional and spatial relationships of components of all systems specified in the Contract Documents, including but not limited to: architectural, structural, civil, mechanical, electrical, fire protection, and specialty systems.
4. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
5. Show location and size of access doors required for access to concealed equipment, fittings, controls, terminations, and cabling.
6. Indicate required installation sequence to minimize conflicts between entities.
7. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Contract Administrator indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
8. The details of the coordination are the responsibility of the Contractor and, where indicated on the Drawings, minor adjustments in raceway routing, device placement, device type, or equipment arrangement are not to be considered changes to the Contract.

B. Equipment Room Coordination Drawings: In accordance with the submittal procedures outlined within these Specifications, provide dimensioned layouts of electrical equipment locations within electrical rooms/closets, mechanical rooms, generator rooms, and fire pump rooms with equipment drawn to scale and identified therein.

1. Clearly identify all required working clearances and access provisions required for installation and maintenance.
2. Equipment layouts should be arranged accounting for considerations for required door openings and the clearances required by the equipment manufacturer.
3. Indicate path to allow for the future removal of each large piece of equipment (up to and including generators and unit sub-station transformers) without removal of non-related equipment or architectural elements.
4. Include work provided by others routed through the equipment rooms.

C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:

1. File Preparation Format: Same digital data software program, version, and operating system as original Drawings.
2. BIM File Incorporation: Develop and incorporate coordination drawing files into Building Information Model established for Project.

    a. Perform three-dimensional component conflict analysis as part of preparation of coordination drawings. Resolve component conflicts prior to submittal. Indicate where conflict resolution requires modification of design requirements by Contract Administrator.

3. Where Henderson Engineer's digital data files are provided to the Contractor for use in preparing coordination digital data files, Henderson Engineers makes no representations as to the accuracy or completeness of digital data files as they relate to the Drawings or Specifications.
4. Submit coordination drawings in accordance with the submittal procedures outlined within these Specifications.

1.7 MEASUREMENTS AND LAYOUTS

A. The drawings are schematic in nature, but show the various components of the systems approximately to scale and attempt to indicate how they are to be integrated with other parts of the building. Figured dimensions shall be taken in preference to scale dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing the Contract Documents. The Contractor will be held responsible for errors which could have been avoided by proper checking and inspection.

1.8 SUBMITTALS

A. Refer to Division 01 and General Conditions for submittal requirements in addition to requirements specified herein.

B. Refer to Division 01 for acceptance of electronic submittals. If not specified by Division 01, provide electronic submittals. If Division 01 requires paper submittals, provide the quantity of submittals required, but no fewer than seven (7) sets.

C. For electronic submittals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Contract Administrator and Engineer that the submittals have been posted. If electronic submittal procedures are not defined in Division 01, Contractor shall include the website, username and password information needed to access the submittals. For submittals sent by e-mail, Contractor shall copy the Contract Administrator's and Engineer's designated representatives. Contractor shall allow for the Engineer Review Time as specified. Contractor shall submit only the documents required to purchase the materials and/or equipment in the submittal.

D. Engineer Review Time: Transmit submittals as early as required to support the project schedule. Allow two weeks for Engineer review time plus to/from mailing time via the Contract Administrator, plus a duplication of this time for resubmittal if required. Transmit submittals as soon as possible after Notice to Proceed and before Mechanical construction starts.

E. Submittals and shop drawings shall not contain the firm name, logo, seal, or signature of the Engineer. They shall not be copies of the work product of the Engineer. If the Contractor desires to use elements of such product, the license agreement for transfer of information obtained from the Engineer must be used.

F. Assemble and submit for review manufacturer product literature for material and equipment to be furnished and/or installed under this Division. Literature shall include shop drawings, manufacturer product data, performance sheets, samples, and other submittals required by this Division as noted in each individual Section. General product catalog data not specifically noted to be part of the specified product will be rejected and returned without review.

G. Separate submittals according to individual specification sections. Only resubmit those sections requested for resubmittal.

H. Provide submittals in sufficient detail so as to demonstrate compliance with these Contract Documents and the design concept. Highlight, mark, list or indicate the materials, performance criteria and accessories that are being proposed. Illegible submittals will be rejected and returned without review.

I. Refer to individual Sections for additional submittal requirements.

J. Before transmitting submittals and material lists, verify that the equipment submitted is mutually compatible with and suitable for the intended use. Verify that the equipment will fit the available space and maintain manufacturer recommended service clearances. If the size of equipment furnished makes necessary any change in location, or configuration, submit a shop drawing showing the proposed layout.

K. Submittals shall contain the following information:

1. The project name.
2. The applicable specification section and paragraph.
3. Equipment identification acronym as used on the drawings.
4. The submittal date.
5. The Contractor's stamp, which shall certify that the stamped drawings have been checked by the Contractor, comply with the Drawings and Specifications, and have been coordinated with other trades.
6. Submittals not so identified will be returned to the Contractor without action.

L. The checking and subsequent acceptance by the Engineer and/or Contract Administrator of submittals shall not relieve responsibility from the Contractor for (1) deviations from Drawings and Specifications; (2) errors in dimensions, details, sizes of equipment, or quantities; (3) omissions of components or fittings; and (4) not coordinating items with actual building conditions and adjacent work. Contractor shall request and secure written acceptance from the Engineer and Contract Administrator prior to implementing any deviation.

M. Provide welders' qualification certificates.

N. BIM Incorporation: Develop and incorporate Shop Drawing files into BIM established for Project.

1.9 SUBSTITUTIONS

A. Refer to Division 01 and General Conditions for Substitutions in addition to requirements specified herein.

B. Materials, products, equipment, and systems described in the Bidding Documents establish a standard of required function, dimension, appearance and quality to be met by the proposed substitution.

C. The base bid shall include only the products from manufacturers specifically named in the drawings and specifications.

D. Request for Substitution:

1. Complete and send the Substitution Request Form attached at the end of this section for each material, product, equipment, or system that is proposed to be substituted.
2. The burden of proof of the merit of the proposed substitution is upon the proposer.
3. Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner the following:

    a. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
    b. Proposed substitution is consistent with the Contract Documents and will produce indicated results, including functional clearances, maintenance service, and sourcing of replacement parts.

c. Proposed substitution has received necessary approvals of authorities having jurisdiction.
d. Same warranty will be furnished for proposed substitution as for specified Work.
e. If accepted substitution fails to perform as required, Contractor shall replace substitute material or system with that originally specified and bear costs incurred thereby.
f. Coordination, installation and changes in the Work as necessary for accepted substitution will be complete in all respects.

E. Substitution Consideration:

1. No substitutions will be considered unless the Substitution Request Form is completed and attached with the appropriate substitution documentation.
2. No substitutions will be considered prior to receipt of Bids unless written request for approval to bid has been received by the Engineer at least ten (10) calendar days prior to the date for receipt of Bids.
3. If the proposed substitution is approved prior to receipt of Bids, such approval will be stated in an Addendum. Bidders shall not rely upon approvals made in any other manner. Verbal approval will not be given.
4. No substitutions will be considered after the Contract is awarded unless specifically provided in the Contract Documents.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 and General Conditions for Operation and Maintenance Manuals in addition to requirements specified herein.

B. Submit manuals prior to requesting the final punch list and before all requests for Substantial Completion.

C. Instruct the Owner's permanent personnel in the proper operation of, startup and shutdown procedures and maintenance of the equipment and components of the systems installed under this Division.

D. Prior to Substantial Completion of the project, furnish to the Architect, for Engineer's review, and for the Owner's use, four (4) copies of Operation and Maintenance Manuals in labeled, hard-back three-ring binders, with cover, binding label, tabbed dividers and plastic insert folders for Record Drawings. Include local contacts, complete with address and telephone number, for equipment, apparatus, and system components furnished and installed under this Division of the specifications.

E. Each manual shall contain data listed in each individual Section.

F. Refer to Division 01 for acceptance of electronic manuals for this project. For electronic manuals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Architect and Engineer that the manuals have been posted. If electronic manual procedures are not defined in Division 01, Contractor shall include the website, user name and password information needed to access the manuals. For manuals sent by e-mail, Contractor shall copy the Architect and Engineer's designated representative.

1.11 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections in Division 23 of this specification.

1.12 RECORD DRAWINGS

A. Refer to Division 01 and General Conditions for Record Drawings in addition to requirements specified herein.

B. A set of work prints of the Contract Documents shall be kept on the jobsite during construction for the purpose of noting changes. During the course of construction, the Contractor shall indicate on these Documents changes made from the original Contract Documents. Particular attention shall be paid to those items which need to be located for servicing. Underground utilities shall be located by dimension from column lines.

C. At the completion of the project, the Contractor shall obtain, at their expense, reproducible copies of the final drawings and incorporate changes noted on the jobsite work prints onto these drawings. These changes shall be done by a skilled drafter. Each sheet shall be marked "Record Drawing", along with the date. These drawings shall be delivered to the Architect/Engineer.

1.13 TRAINING

A. Provide training as indicated in each specific section to demonstrate the systems to the owner. All features and functions shall be explained and the owner shall be instructed on proper operation and maintenance of the system including drain and freeze protection requirements during winter conditions. Schedule training with the Owner at least 7 days in advance after systems have been tested, balanced, and placed in proper working order but before final acceptance of the mechanical systems. Video record the training sessions in format as agreed to with the Owner. Provide three copies of each session to the Owner and obtain written receipt from the Owner. Provide a certificate to owner certifying demonstrations have been completed including the system demonstrated, dates demonstrations were performed, and names of personnel in attendance signed by Contractor and Owner.

1.14 PAINTING

A. Exposed ductwork and ferrous surfaces, including pipe, pipe hangers, equipment stands and supports [and exposed insulated piping] shall be painted by the Contractor using materials and methods as specified under Division 09 of the Specifications; colors shall be as selected by the Architect.

B. Factory finishes, shop priming and special finishes are specified in the individual equipment specification sections.

C. Where factory finishes are provided and no additional field painting is specified, marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish.

1.15 DELIVERY, STORAGE AND HANDLING

A. Refer to Division 01 and General Conditions for Delivery, Storage and Handling in addition to requirements specified herein.

B. Equipment and material shall be delivered to the job site in their original containers with labels intact, fully identified with manufacturer's name, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.

C. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and at all times, take every precaution to properly protect equipment and material from damage, to include the erection of temporary shelters to adequately protect equipment and material stored at the Site. Equipment and/or material which become rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to the Architect.

D. The Contractor shall be responsible for the safe storage of their own tools, material and equipment.

1.16 GUARANTEES AND WARRANTIES

A. Refer to Division 01 and General Conditions for Guarantees and Warranties in addition to requirements specified herein.

B. Each system and element thereof shall be warranted against defects due to faulty workmanship, design or material for a period of 12 months from date of Substantial Completion, unless specific items are noted to carry a longer warranty in the Construction Documents or manufacturer's standard warranty. The Contractor shall remedy defects occurring within a period of one year from the date of Substantial Completion or as stated in the General Conditions.

C. The following additional items shall be guaranteed:

1. Piping shall be free from obstructions, holes or breaks of any nature.
2. Insulation shall be effective.
3. Proper circulation of fluid in each piping system.

D. The above guarantees shall include both labor and material; and repairs or replacements shall be made without additional cost to the Owner.

E. The remedial work shall be performed promptly, upon written notice from the Architect or Owner.

F. At the time of Substantial Completion, deliver to the Owner warranties with terms extending beyond the one year guarantee period, each warranty instrument being addressed to the Owner and stating the commencement date and term.

1.17 TEMPORARY FACILITIES

A. Refer to Division 01 and General Conditions for Temporary Facilities requirements in addition to requirements specified herein.

B. Temporary Utilities: The types of services required include, but are not limited to, water, sewerage, surface drainage and gas. When connecting to existing franchised utilities for required services, comply with service companies' recommendations on materials and methods, or

engage service companies to install services. Locate and relocate services (as necessary) to minimize interference with construction operations.

1. Provide the necessary backflow prevention devices where connecting to the potable water system. Protect water service from freezing by draining system or by providing adequate heat. Where non-potable water is used, mark each outlet with health hazard warning signs.
2. Sewer Sediment: Maintain sewers and temporary connecting sewers in a clean, non-clogged condition during construction period.

C. Construction Facilities: Provide facilities reasonably required to perform construction operations properly and adequately.

1. Enclosures: When temporary enclosures are required to ensure adequate workmanship, weather protection and ambient conditions required for the work, provide fire-retardant treated lumber and plywood; provide tarpaulins with UL label and flame spread of 15 or less; provide translucent type (nylon reinforced polyethylene) where daylighting of enclosed space would be beneficial for workmanship, and reduce use of temporary lighting.
2. Heating: Provide heat, as necessary, to protect work, materials and equipment from damage due to dampness and cold. In areas where building is occupied, maintain a temperature not less than 65 degrees Fahrenheit. Use steam, hot water, or gas from piped distribution system where available. Where steam, hot water or piped gas are not available, heat with self-contained LP gas or fuel oil heaters, bearing UL, FM or other approval labels appropriate for application. Vent fuel-burning heaters, and equip units with individual-space thermostatic controls. Use electric-resistance space heaters only where no other, more energy-efficient, type of heater is available and allowable.

1.18 PROJECT CONDITIONS

A. Conditions Affecting Work In Existing Buildings:

1. The Drawings describe the general nature of remodeling to the existing building. However, the Contractor shall visit the Site prior to submitting their bid to determine the nature and extent of work involved.
2. Work in the existing building shall be scheduled with the Owner.
3. Certain demolition work must be performed prior to the remodeling. The Mechanical Contractor shall perform the demolition which involves Mechanical systems, equipment, piping, equipment supports or foundations and materials.
4. Mechanical Contractor shall remove articles which are not required for the new Work. Unless otherwise indicated, each item removed by the Mechanical Contractor during this demolition shall become their property and shall be removed by the Mechanical Contractor from the premises and dispose of them in accordance with applicable federal, state and local regulations.
5. Mechanical Contractor shall relocate and reconnect Mechanical facilities that must be relocated in order to accomplish the remodeling shown in the Drawings or indicated in the Specifications. Where Mechanical equipment or materials are removed, the Mechanical Contractor shall cap unused piping beyond the floor line or wall line to facilitate restoration of finish.
6. General Contractor shall install finish material.
7. Obtain permission from the Architect for channeling of floors or walls not specifically noted on the Drawings.
8. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.

9. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

B. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.

C. Use of explosives is not permitted.

D. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

PART 2 - PRODUCTS AND MATERIALS

2.1 NOT USED

PART 3 - EXECUTION

3.1 PERMITS

A. Secure and pay for permits required in connection with the installation of the Mechanical Work. Arrange with the various utility companies for the installation and connection of required utilities for this facility and pay charges associated therewith including connection charges and inspection fees, except where these services or fees are designated to be provided by others.

3.2 EXISTING UTILITIES

A. Schedule and coordinate with the Utility Company, Owner and with the Engineer connection to, or relocation of, or discontinuation of normal utility services from existing utility lines. Premium time required for any such work shall be included in the bid.

B. Existing utilities damaged due to the operations of utility work for this project shall be repaired to the satisfaction of the Owner or Utility Company without additional cost.

C. Utilities shall not be left disconnected at the end of a work day or over a weekend unless authorized by representatives of the Owner or Engineer.

D. Repairs and restoration of utilities shall be made before workmen leave the project at the end of the workday in which the interruption takes place.

E. Contractor shall include in their bid the cost of furnishing temporary facilities to provide services during interruption of normal utility service.

3.3 SELECTIVE DEMOLITION

A. Refer to Division 02 and General Conditions for Selective Demolition requirements in addition to the requirements specified herein.

B. General: Demolish, remove, demount, and disconnect abandoned mechanical materials and equipment indicated to be removed and not indicated to be salvaged or saved.

C. Materials and Equipment to Be Salvaged: Remove, demount, and disconnect existing mechanical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.

D. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

E. Mechanical Materials and Equipment: Demolish, remove, demount, and disconnect the following items:

1. Inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, and insulation.

    a. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove exposed materials and materials above accessible ceilings. Drain and cap piping and ducts allowed to remain.
    b. Perform cutting and patching required for demolition in accordance with Division 01, General Conditions and "Cutting and Patching" portion of this Section in Division 23.

F. Provide schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.

1. Coordinate sequencing with construction phasing and Owner occupancy specified in Division 01 Section "Summary of Work."

3.4 CUTTING AND PATCHING

A. Cut walls, floors, ceilings, and other portions of the facility as required to install work under this Division.

B. Obtain permission from the Architect prior to cutting. Do not cut or disturb structural members without prior approval from the Architect and Structural Engineer.

C. For post-tension slabs, x-ray slab and closely coordinate all core drill locations with Architect and Structural Engineer prior to performing any work. Obtain approval from Architect and Structural Engineer for all core drills and penetrations at least four days prior to performing work.

D. Penetrations shall be made as small as possible while maintaining required clearances between the building element penetrated and the system component.

E. Patch around openings to match adjacent construction, including fire ratings, if applicable.

F. Repair and refinish areas disturbed by work to the condition of adjoining surfaces in a manner satisfactory to the Architect.

3.5 CLEANING

A. Dirt and refuse resulting from the performance of the work shall be removed from the premises as required to prevent accumulation. The Mechanical Contractor shall cooperate in maintaining reasonably clean premises at all times.

B. Immediately prior to the final inspection, the Mechanical Contractor shall clean material and equipment installed under the Mechanical Contract. Dirt, dust, plaster, stains, and foreign matter shall be removed from surfaces including components internal to equipment. Damaged finishes shall be touched-up and restored to their original condition.

3.6 SUBSTANTIAL COMPLETION REVIEW

A. Prior to requesting inspection for "CERTIFICATE OF SUBSTANTIAL COMPLETION", the Contractor shall complete the following items:

1. Submit complete Operation and Maintenance Manuals.
2. Submit complete Record Drawings.
3. Perform special inspections as required in each individual Section.
4. Start-up testing of systems.
5. Removal of temporary facilities from the site.
6. Comply with requirements for Substantial Completion in the "General Conditions".

B. The Contractor shall request in writing a review for Substantial Completion. The Contractor shall give the Architect/Engineer at least seven (7) days notice prior to the review.

C. The Contractor's written request shall state that the Contractor has complied with the requirements for Substantial Completion.

D. Upon receipt of a request for review, the Architect/Engineer will either proceed with the review or advise the Contractor of unfulfilled requirements.

E. If the Contractor requests a site visit for Substantial Completion review prior to completing the above mentioned items, the Contractor shall reimburse the Architect/Engineer for time and expenses incurred for the visit.

F. Upon completion of the review, the Architect/Engineer will prepare a "final list" of outstanding items to be completed or corrected for final acceptance.

G. Omissions on the "final list" shall not relieve the Contractor from the requirements of the Contract Documents.

H. Prior to requesting a final review, the Contractor shall submit a copy of the final list of items to be completed or corrected. The Contractor shall state in writing that each item has been completed, resolved for acceptance or the reason it has not been completed.

END OF SECTION

SUBSTITUTION REQUEST FORM

To Project Engineer: _____ Request # (GC Determined): _____

Project Name: _____

Project No/Phase: _____ Date: _____

Specification Title: _____

Section Number: _____ Page: _____ Article/Paragraph: _____

Proposed Substitution: _____

_____

Manufacturer: _____ Model No.: _____

Address: _____ Phone: _____

History: ☐ New product ☐ 1-4 years old ☐ 5-10 years old ☐ More than 10 years old

Differences between proposed substitution and specified Work: _____

_____

☐ Point-by-point comparative data attached – REQUIRED BY ENGINEER
Comparative data may include but not be limited to performance, certifications, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements. Include all information necessary for an evaluation.

Supporting Data Attached: ☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐ Other: _____

Reason for not providing specified item: _____

_____

Similar Installation:
Project: _____ Architect: _____

Address: _____ Owner: _____

_____ Date Installed: _____

Proposed substitution affects other parts of Work: ☐ No ☐ Yes; explain: _____

_____

_____

Substitution Certification Statement:

Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner that the:

A. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
B. Proposed substitution is consistent with the Contract Documents and will produce indicated results.
C. Proposed substitution does not affect dimensions and functional clearances.
D. Proposed substitution has received necessary approvals of authorities having jurisdiction.
E. Same warranty will be furnished for proposed substitution as for specified Work.
F. Same maintenance service and source of replacement parts, as applicable, is available.
G. Proposed substitution will not adversely affect other trades or delay construction schedule.
H. Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitting Contractor	Date	Company

Manufacturer's Certification of Equal Quality:

I _____ represent the manufacturer of the Proposed Substitution item and hereby certify and warrant to Architect, Engineer, and Owner that the function and quality of the Proposed Substitution meets or exceeds the Specified Item.

Manufacturer's Representative	Date	Company

Engineer Review and Recommendation Section

Recommend Acceptance	☐ Yes	☐ No
Additional Comments:	☐ Attached	☐ None

Acceptance Section:

Contractor Acceptance Signature	Date	Company
Owner Acceptance Signature	Date	Company
Architect Acceptance Signature	Date	Company
Engineer Acceptance Signature	Date	Company

SECTION 230015 - ELECTRICAL COORDINATION FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section specifies the basic requirements for electrical components which are an integral part of packaged mechanical equipment. These components include, but are not limited to factory furnished motors, starters, and disconnect switches furnished as an integral part of packaged mechanical equipment.

B. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

C. System shall be complete and operational with power and control wiring provided to meet the design intent shown on the drawings and specified within the specification sections.

1.2 SUBMITTALS

A. No separate submittal is required. Submit product data for motors, starters, and other electrical components with submittal data required for the equipment for which it serves, as required by the individual equipment specification Sections.

1.3 QUALITY ASSURANCE

A. Electrical components and materials shall be UL labeled.

B. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of this Section and Division 26.

PART 2 - PRODUCTS AND MATERIALS

2.1 GENERAL

A. The Contractors shall provide all motors, starters, disconnects, wire, conduit, etc. as specified in the Construction Documents. If, however, the Division 23 Contractor furnishes a piece of equipment requiring a different motor, starter, disconnect, wire size, etc. than what is shown and/or intended on the Construction Documents, this Contractor shall coordinate the requirements with any other Contractor and shall be responsible for any additional cost incurred by any other Contractor that is associated with installing the different equipment and related accessories for proper working condition.

B. Refer to Division 26, "COMMON WORK RESULTS FOR ELECTRICAL" for specification of motor connections.

C. Refer to Division 26, "ENCLOSED CONTROLLERS" for specification of motor starters.

D. Refer to Division 26, "ENCLOSED SWITCHES AND CIRCUIT BREAKERS" for specification of disconnect switches and enclosed circuit breakers.

PART 3 - EXECUTION

3.1 CONTRACTOR COORDINATION

A. Unless otherwise indicated, all motors, equipment, controls, etc. shall be furnished, set in place and wired in accordance with Table 1. Any items not listed but shown on the drawings shall be considered part of the Contract Documents and brought to the attention of the Architect.

B. The General Contractor is the central authority governing the total responsibility of all trade contractors. Therefore, deviations and clarifications of this schedule are permitted provided the General Contractor assumes responsibility to coordinate the trade contractors different than as indicated herein. If deviations or clarifications to this schedule are implemented, submit a record copy to the Engineer.

TABLE 1: ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

ITEM	FURN BY	SET BY	POWER WIRING	CONTROL WIRING
Equipment motors	DIV23m	DIV23m	DIV26	---
Factory furnished motor starters contactors and disconnects	DIV23m	DIV23m	DIV26	DIV23t
Loose motor starters, disconnect switches, thermal overloads and heaters.	DIV26	DIV26	DIV26	DIV23t
Variable speed drives	DIV23m	DIV23m	DIV26	DIV23t
Manual operating multi-speed switches	DIV23m	DIV26	DIV26	DIV23t
Control relays	DIV23t	DIV23t	DIV26	DIV23t
Thermostats (low voltage)	DIV23t	DIV23t	---	DIV23t
Time switches (for mechanical equipment)	DIV23t	DIV23t	DIV26	DIV23t
Control power transformers	DIV23t	DIV23t	DIV26	DIV23t
Control power transformers furnished with equipment	DIV23m	DIV23m	DIV26	DIV23t
Temperature control panels (housing controllers)	DIV23t	DIV23t	DIV26	DIV23t
Building controllers, advanced application controllers, and application specific controllers	DIV23t	DIV23t	DIV23t	DIV23t
Damper operators, PE & switches	DIV23t	DIV23t	DIV23t	DIV23t
Duct Smoke detectors	DIV28	DIV23m	DIV28	DIV28
Refrigeration equipment and controls	DIV23m	DIV23m	DIV26	DIV23t
Pushbutton stations and connections	DIV23m	DIV23m	DIV26	DIV23t
Temporary heating connections	DIV23m	DIV23m	DIV26	DIV23m
Interlocks between air handling units and exhaust fans	---	---	---	DIV23m
Interlocks between HVAC fans and damper operators	---	---	DIV26	DIV23t

DIV23m = Mechanical Contractor
DIV23t = Temperature Controls Sub-Contractor
DIV26 = Electrical Contractor
DIV28 = Electronic Safety and Security

END OF SECTION

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with mechanical installations as follows:

1. Access panels and doors in walls, ceilings, and floors for access to mechanical materials and equipment.
2. Mechanical equipment nameplate data.
3. Concrete for bases and housekeeping pads.
4. Non-shrink grout for equipment installations.
5. Sleeves for mechanical penetrations.
6. Miscellaneous metals for support of mechanical materials and equipment.
7. Wood grounds, nailers, blocking, fasteners, and anchorage for support of mechanical materials and equipment.
8. Joint sealers for sealing around mechanical materials and equipment.
9. Firestopping

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 07 Section "Penetration Firestopping" for material and methods for firestopping systems.
2. Division 23 Section "Basic Piping Materials and Methods," for materials and methods for mechanical sleeve seals.
3. Division 26 Section "Common Work Results for Electrical" required electrical devices.
4. Division 26 Sections "Enclosed Switches and Circuit Breakers" for field-installed disconnects.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 23 Section General Mechanical Requirements.

1. Product data for the following products:

   a. Access panels and doors.
   b. Joint sealers.
   c. Through and membrane-penetration firestopping systems.
2. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for mechanical materials and equipment.
3. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of utility services and details for dust and noise control.

   a. Coordinate sequencing with construction phasing and Owner occupancy specified in Division 01 Section "Summary of Work."

4. Through and Membrane Penetration Firestopping Systems Product Schedule: Submit a schedule for each piping system penetration that includes UL listing, location, wall or floor rating and installation drawing for each penetration fire stop system.

    a. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping condition, submit illustration, with modifications marked, approved by penetration firestopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.3 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.

1. Provide UL Label on each fire-rated access door.

C. Through and Membrane Penetration Firestopping Systems Installer Qualifications: A firm experienced in installing penetration firestopping systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping system products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

PART 2 - PRODUCTS AND MATERIALS

2.1 ACCESS TO EQUIPMENT

A. Manufacturers:

1. Bar-Co., Inc.
2. Elmdor Stoneman.
3. JL Industries
4. Jay R. Smith Mfg. Co.
5. Karp Associates, Inc.
6. Milcor
7. Nystrom Building Products
8. Wade
9. Zurn

B. Access Doors:

1. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
2. Frames: 16-gauge steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.

    a. For installation in masonry, concrete, ceramic tile, or wood paneling: 1-inch-wideexposed perimeter flange and adjustable metal masonry anchors.
    b. For installation in gypsum wallboard or plaster: perforated flanges with wallboard bead.
    c. For installation in full-bed plaster applications: galvanized, expanded metal lath and exposed casing bead, welded to perimeter of frame.

3. Flush Panel Doors: 14-gauge sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.

    a. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.

4. Locking Devices: Flush, screwdriver-operated cam locks.

2.2 MECHANICAL EQUIPMENT NAMEPLATE DATA

A. For each piece of power operated mechanical equipment, provide a permanent operational data nameplate indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance's, and similar essential data. Locate nameplates in an accessible location.

2.3 CONCRETE EQUIPMENT BASES/HOUSEKEEPING PADS

A. Provide concrete equipment bases and housekeeping pads for various pieces of floor mounted mechanical equipment. Concrete equipment bases/housekeeping pads shall generally conform to the shape of the piece of equipment it serves with a minimum 4" margin around the equipment and supports.

B. Form concrete equipment bases and housekeeping pads using framing lumber or steel channel with form release agent. Chamfer top edges and corners. Trowel tops and sides of each base/pad to a smooth finish, equal to that of the floors.

C. Concrete equipment bases and housekeeping pads shall be made of a minimum 28 day, 4000 psi concrete conforming to American Concrete Institute Standard Building Code for Reinforced Concrete (ACI 318-99) and the latest applicable recommendations of the ACI standard practice manual. Concrete shall be composed of cement conforming to ASTM C 150 Type I, aggregate conforming to ASTM C33, and potable water. All exposed exterior concrete shall contain 5 to 7 percent air entrainment.

D. Unless otherwise specified or shown on the structural drawings, reinforce equipment bases and housekeeping pads with No. 4 reinforcing bars conforming to ASTM A 615 or 6x6 – W2.9 x W2.9 welded wire mesh conforming to ASTM A185. Reinforcing bars shall be placed 24" on center with a minimum of two bars each direction.

E. Provide galvanized anchor bolts for all equipment placed on concrete equipment bases and housekeeping pads or on concrete slabs. Anchor bolts size, number and placement shall be as recommended by the Manufacturer of the equipment.

F. Concrete equipment bases and housekeeping pads shall have height as specified on the drawings or minimum height if not specified in accordance with the following table:

Equipment	Minimum Height
Furnaces, Exterior Equipment Less than or equal to 20 tons and Other Equipment Not Listed	3-1/2"

NOTES:

1. Height of equipment bases applies to equipment installed on slab-on-grade. For equipment installed on floors above grade and/or roof, reference the drawings.
2. Coordinate final pad heights for air handling units with required condensate trap depths. Increase pad heights as needed to allow for unit trap height and required slope to drain.

2.4 GROUT

A. Provide nonshrink, nonmetallic grout conforming to ASTM C 1107, Grade B, in premixed and factory-packaged containers.

B. Grout shall have post-hardening, volume-adjusting, dry, non-staining, non-corrosive, non-gaseous, hydraulic-cement characteristics and shall be as recommended by manufacturer for interior and exterior applications.

C. Grout shall have 5,000 psi, 28-day compressive strength design mix.

2.5 PENETRATIONS

A. Sleeves:

1. Steel Sleeves: Schedule 40 galvanized, welded steel pipe, ASTM A-53 grade A or 12 gauge (0.1084 inches) welded galvanized steel formed to a true circle concentric to the pipe.
2. Sheet-Metal Sleeves: 10 gauge (0.1382 inches), galvanized steel, round tube closed with welded longitudinal joint.

B. Frames for rectangular openings attached to forms and of a maximum dimension established by the Architect. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, provide 18 gauge (0.052 inches) welded galvanized steel. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, provide 10 gauge (0.1382 inches) welded galvanized steel. Notify the General Contractor or Architect before installing any box openings not shown on the Architectural or Structural Drawings.

2.6 MISCELLANEOUS METALS

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold-Formed Steel Tubing: ASTM A 500.

C. Hot-Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Fasteners: Zinc-coated, type, grade, and class as required.

2.7 MISCELLANEOUS LUMBER

A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.

B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less that 15/32 inches.

2.8 JOINT SEALERS

A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

B. Colors: As selected by the Architect from manufacturer's standard colors.

C. Nonacid Curing Sealer: One-part, nonacid-curing, silicone sealant complying with ASTM C920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.

1. Manufacturers:

a. Dow Corning, Dowsil 790.
b. Dow Corning, Dowsil 795.
c. GE, Silglaze II SCS 2350.
d. GE, Silpruf SCS 2000.
e. Owens Corning, Energy Complete.
f. Pecora, 864 NST.
g. Tremco, Spectrem 1.
h. Tremco, Spectrem 2.

D. High Humidity Sealer: One-part, mildew-resistant, silicone sealant complying with ASTM C920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.

1. Manufacturers:

a. Dow Corning, Dowsil 786.
b. GE, Momentum SCS1700.
c. Pecora, 898 Silicone NST.

E. Hybrid Joint Sealer: One-part, non-sag, paintable complying with ASTM C920, Type S, Grade NS, Class 50, recommended for exposed applications on interior and exterior locations involving joint movement of not more than plus or minus 50 percent.

1. Manufacturers:

    a. BASF, MasterSeal NP 100.
    b. Pecora, DyanTrol I-XL.
    c. Tremco, Dymonic FC.

F. Acrylic Latex Joint Sealer: One-part, non-sag, mildew-resistant, paintable acrylic latex or siliconized acrylic latex, complying with ASTM C834, Type OP, Grade NF, recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent.

1. Manufacturers:

    a. Pecora, AC-20
    b. Sherwin Williams 950A
    c. Tremco, Tremflex 834

2.9 FIRESTOPPING

A. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with UL 2079 or ASTM E814, or other NRTL acceptable to AHJ.

B. Manufacturers:

1. 3M Corp., Fire Barrier Sealant.
2. Hilti.
3. Owens Corning, Firestopping Insulation.
4. Pecora, AC-20 FTR.
5. RectorSeal.
6. Specified Technologies Inc., Firestop.
7. USG SHEETROCK Firecode Compound.
8. Tremco, Tremstop Fyre-Sil.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

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

3.2 INSTALLATION OF ACCESS DOORS

A. Provide access doors for all concealed equipment and duct and piping accessories that require service where indicated or as required, except where above lay-in ceilings. Refer to Section "Identification for HVAC Piping and Equipment" for labeling of access doors.

B. Access doors shall be adequately sized for the devices served with a minimum size of 18 inches x 18 inches, furnished by the respective Contractor or Subcontractor and installed by the General Contractor.

C. Access doors must be of the proper construction for type of construction where installed.

D. The exact location of all access doors shall be verified with the Architect prior to installation.

E. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

F. Adjust hardware and panels after installation for proper operation.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS "Structural Welding Code."

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.5 PREPARATION FOR JOINT SEALERS

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.6 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

3.7 PENETRATIONS:

A. New Construction:

1. Coordinate with Divisions 03 and 04 for installation of sleeves and sleeve seals integrally in cast-in-place, precast, and masonry walls and horizontal slabs where indicated on the Drawings or as required to support piping or ductwork penetrations.

B. Construction in Existing Facilities:

1. Saw cut or core drill existing walls and slabs to install sleeves and sleeve seals in existing facilities. Do not cut or drill any walls or slabs without first coordinating with, and receiving approval from, the Architect, Owner, or both. Seal sleeves and sleeve seals into concrete walls or slabs with a waterproof non-shrink grout acceptable to the Architect.

C. Provide sleeves and/or box frames for openings in all concrete and masonry construction and fire or smoke partitions, for all mechanical work that passes through such construction; Coordinate with other trades and Divisions to dimension and lay out all such openings.

D. The General Contractor will provide only those openings specifically indicated on the Architectural or Structural Drawings as being provided under the General Contractor's work.

E. The cutting of new or existing construction shall not be permitted except by written approval of the Architect.

F. Floor sleeves shall be fitted with means for attachment to forms and shall be of length to extend at least two inches above the floor level.

G. All sleeves shall be of ample size to allow for movement of conduit, duct or pipe and insulation through the sleeves without damage to the insulation.

H. Cut sleeves to length for mounting flush with both surfaces of walls.

I. Extend sleeves installed in floors 2 inches above finished floor level.

J. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

K. Seal space outside of sleeves with approved joint compound for penetrations of gypsum board assemblies.

L. All circular and oval openings sleeved through underground exterior walls shall be sealed with mechanical sleeve seals as specified in Division 23 Section "Basic Piping Materials and Methods". All rectangular openings through underground exterior walls shall be flanged and flashed with non-corrosive material on each side and the gap sealed with weatherproof sealant.

END OF SECTION

SECTION 230510 - BASIC PIPING MATERIALS AND METHODS

PART 1 - GENERAL REQUIREMENTS

1.1 SECTION INCLUDES

A. Joining materials.

B. Escutcheons.

C. Nipples.

D. Unions.

E. Mechanical sleeve seals.

F. Pipe roof curbs.

1.2 SUBMITTALS

A. Refer to Division 01 and Division 23 Section "General Mechanical Requirements" for administrative and procedural requirements for submittals.

B. Product Data, including, rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions.

C. Quality Assurance Submittals: Submit welders' certificates specified in Article "Quality Assurance" below.

D. Piping Schedule: Submit a piping schedule that states the material being proposed for each piping system application in the project including manufacturer's catalog information, pipe materials, sizes, fittings, Type, Grade, Schedule, applicable ASTM standard, and connection method(s).

E. Submit a schedule of dissimilar metal joints and dielectric flanges, flange kits, unions, or waterway fittings. Include proposed product, joint type materials, and connection method to isolate dissimilar metals. Refer to the individual Division 23 piping system specification sections for piping materials and fittings relative to that particular system and additional requirements.

F. Submit certification that fittings and specialties are manufactured in plants located in the United States or certified that they comply with applicable ANSI and ASTM standards.

G. Manufacturer's Installation Instructions: Indicate hanging and support methods and joining procedures.

H. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

I. Shop Drawings: Include detailed fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure.

J. Coordination Drawings: Include piping layout, 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. Other building services.
3. Structural members.

K. As-built drawings for each piping system in electronic and PDF format.

L. Refer to the individual piping system specification sections in Division 23 for additional requirements.

1.3 QUALITY ASSURANCE

A. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code (BPVC), Section IX, "Welding, Brazing, and Fusing Qualifications."

B. Comply with ASME B31.9 - Building Services Piping, most recent edition.

C. Soldering and Brazing procedures shall conform to ANSI B9.1 Safety Code for Mechanical Refrigeration.

D. Pipe specialties and fittings shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ASME, and ANSI standards.

E. Refer to the individual piping system specification sections in Division 23 for additional requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

C. Refer to the individual piping system specification sections in Division 23 for additional requirements.

PART 2 - PRODUCTS AND MATERIALS

2.1 PIPE AND FITTINGS

A. Refer to the individual piping system specification sections in Division 23 for specifications on piping and fittings relative to that particular system.

2.2 JOINING MATERIALS

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

B.

C. Brazing Filler Metals: Comply with SFA-5.8, Section II, ASME BPVC for brazing filler metal materials appropriate for the materials being joined.

1. AWS A5.8, Classification BAg–5:

a. Silver (Ag) 44.0 – 46.0 percent.
b. Zinc (Z) 23.0 – 27.0 percent.
c. Copper (Cu) 29.0 – 31.0 percent.

2. AWS A5.8, Classification BCuP–5:

a. Phosphorus (P) 4.8 - 5.2 percent.
b. Silver (Ag) 14.5 - 15.5 percent.
c. Copper (Cu) remainder.

D. Soldering Filler Metals: ASTM B32, 95-5 Tin-Antimony and water flushable flux in accordance with ASTM B813.

2.3 ESCUTCHEONS

A. Manufacturers:

1. AWI Manufacturing.
2. Keeney Manufacturing Company.
3. Wal-Rich Corp.
4. Jones Stephens Corp.
5. Approved equal.

B. Chrome-plated, stamped-steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit pipe outside diameter, or outside of pipe insulation where pipe is insulated. Outside diameter shall completely cover the opening in floors, walls, or ceilings.

2.4 NIPPLES

A. Steel: ASTM A733, made of ASTM A53, Schedule 40, black steel; Type S seamless for pipe sizes 2 inch and smaller, Type E electric-resistance welded for pipe sizes 2-1/2 inch and larger.

2.5 UNIONS:

A. Manufacturers:

1. Anvil International.
2. Hart Industries.
3. Mueller Streamline Co.
4. Victaulic Company of America.
5. Watts Regulator Co.
6. Approved equal.

B. Hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

1. Malleable-iron: ASME B16.39, class as specified in section "Hydronic Piping" for the piping system used.
2. Bronze: ASME B16.15, cast bronze body meeting ASTM B62, class as specified in section "Hydronic Piping" for the piping system used.
3. Copper: ASME B16.22 wrought copper body.

    a. For hydronic systems, provide class as specified in section "Hydronic Piping" for the piping system used.
    b. For refrigerant systems, provide pressure rating as required for the refrigerant type used.

2.6 MECHANICAL SLEEVE SEALS

A. Manufacturers:

1. Thunderline/Link Seal.
2. Calpico, Inc.
3. Metraflex Co.
4. Approved equal.

B. Sleeves: Refer to Division 23 Section "Common Work Results for HVAC" for sleeve materials.

C. Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.7 PIPE ROOF CURBS

A. Manufacturers:

1. AES Industries.
2. Custom Curb, Inc.
3. Pate Company.
4. Thybar.

B. Provide factory-fabricated, pipe roof curbs with the following features:

1. Factory installed treated wood nailer.
2. Welded, 18 gauge galvanized steel shell, base plate and flashing.
3. 1-1/2 inch thick, 3 pound rigid insulation.
4. Fully mitered 3-inch raised cant.
5. Cover of weather-resistant, weather-proof material.
6. Pipe collar of weather-resistant material with stainless steel pipe clamps.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.

3.2 INSTALLATION, GENERAL

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

B. Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated. Refer to individual system specifications for requirements for coordination drawing submittals.

C. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

D. Install piping free of sags and bends and with ample space between piping to permit proper insulation applications.

E. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Drawings.

F. Install horizontal piping as high as possible allowing for specified slope and coordination with other components. Install vertical piping tight to columns or walls. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

G. Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

H. Support piping from structure. Do not support piping from ceilings, equipment, ductwork, conduit and other non-structural elements.

I. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4 inch ball valve, and short 3/4 inch threaded nipple and cap.

J. Verify final equipment locations for roughing in.

K. Use fittings for all changes in direction and all branch connections.

L. Remake leaking joints using new materials.

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

N. Piping Protection:

1. Protect piping during construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.
2. Place plugs in ends of uncompleted piping at end of day or whenever work stops.

3.3 PENETRATIONS

A. Mechanical penetrations occur when piping or ductwork penetrate concrete slabs, concrete or masonry walls, or fire / smoke rated floor and wall assemblies. Reference Division 23 Section "Common Work Results for HVAC" for additional penetration requirements.

B. Above Grade Concrete or Masonry Penetrations:

1. Provide sleeves for pipes passing through above grade concrete or masonry walls, concrete floor or roof slabs. Sleeves are not required for core drilled holes in existing masonry walls, concrete floors or roofs.

    a. Provide Schedule 40 galvanized steel pipe for sleeves smaller than 6 inches in diameter.
    b. Provide galvanized sheet metal for sleeves 6 inches in diameter and larger, thickness shall be 10 gauge (0.1382 inches).
    c. Provide welded galvanized sheet metal for rectangular sleeves with the following minimum metal thickness:

        1) For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 18 gauge (0.052 inches).
        2) For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 10 gauge (0.1382 inches).

    d. Schedule 40 PVC pipe sleeves are acceptable for use in areas without return air plenums.

2. Extend pipe insulation for insulated pipe through floor, wall and roof penetrations, including fire rated walls and floors. The vapor barrier shall be maintained. Size sleeve for a minimum of 1 inch annular clear space between inside of sleeve and outside of insulation.
3. Seal elevated floor, exterior wall and roof penetrations watertight and weathertight with non-shrink, non-hardening commercial sealant. Pack with mineral wool and seal both ends with minimum of 1/2 inch of sealant.

C. Elevated Floor Penetrations of Waterproof Membrane:

1. Provide cast-iron sleeves, extend top of sleeve minimum 1 inch above finish floor. Size sleeve for minimum 1/2 inch annular space between pipe and sleeve.
2. Extend pipe insulation for insulated pipe through sleeve. The vapor barrier shall be maintained. Size sleeve for a minimum of 1 inch annular clear space between inside of sleeve and outside of insulation.
3. Pack with mineral wool and seal both ends with minimum of 1/2 inch of waterproof sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.
4. Secure waterproof membrane flashing between clamping flange and clamping ring. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
5. Extend bottom of sleeve below floor slab as required and secure underdeck clamp to hold sleeve rigidly in place.

D. Interior Penetrations of Non-Fire-Rated Walls:

1. Seal annular space between sleeve and pipe or duct, using joint sealant appropriate for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum

of 1/2 inch of sealant. Refer to Division 07 Section "Joint Sealants" for materials and installation.

2. Extend pipe insulation for insulated pipe through sleeve. The vapor barrier shall be maintained. Size sleeve for a minimum of 1 inch annular clear space between inside of sleeve and outside of insulation.

E. Fire / Smoke Rated Floor and Wall Assemblies:

1. Seal around penetrations of fire rated assemblies to maintain fire resistance rating of fire-rated assemblies. Coordinate fire ratings and locations with the architectural drawings. Install sealants in compliance with the manufacturer's UL listing. Refer to Division 07 Section "Penetration Firestopping" for special sealers and materials.

3.4 PIPE JOINT CONSTRUCTION

A. Brazed and Soldered Joints:

1. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."
2. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."
3. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.
4. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
1. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making joint.
2. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
5. Copper-to-copper joints shall be made using BCuP-5 brazing filler metal without flux.
6. Dissimilar metals such as copper and brass shall be jointed using an appropriate flux with either BCuP-5 or BAg-5 brazing filler metal. Apply flux sparingly to the clean tube only and in a manner to avoid leaving any excess inside the completed joint.
7. Continuously purge the pipe and fittings during brazing with an inert gas (i.e., dry nitrogen or carbon dioxide) to prevent formation of scale. Maintain purge until the joint is cool to the touch.
8. Heat joints using oxy-acetylene torch. Heat to proper and uniform temperature.
9. Provide temporary cap or cover on completed joints with open ends to prevent entry of contaminating materials.

B. Mechanical Refrigerant Pipe Joints: Flared compression fittings may be used for refrigerant lines 3/4 inch and smaller.

C. Joints for other piping materials are specified within the respective piping system Sections.

3.5 PIPE FIELD QUALITY CONTROL

A. Testing: Refer to individual piping system specification sections.

END OF SECTION 230510

SECTION 230513 - COMMON MOTOR REQUIREMENT FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General construction and requirements.

B. Applications.

C. Single phase electric motors.

D. Three phase electric motors.

E. Electronically Commutated Motors (ECM).

F. Capacitors.

1.2 REFERENCE STANDARDS

A. ABMA STD 9 – Load Ratings and Fatigue Life for Ball Bearings; most recent edition.

B. IEEE 112 – IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; most recent edition.

C. NEMA MG 1 – Motors and Generators; most recent edition.

D. NFPA 70 – National Electrical Code; most recent edition adopted by the Authority Having Jurisdiction, including all applicable amendments and supplements.

1.3 SUBMITTALS

A. Conform with the submittal procedures in Division 01.

B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements. Provide nameplate data and ratings, mounting arrangements, size and location of winding termination lugs, overload relays, conduit entry, grounding lug, and coatings.

C. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.

D. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

E. Operation Data: Include instructions for safe operating procedures.

F. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY STORAGE AND HANDLING.

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.6 WARRANTY

A. Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Baldor Electric Company.

B. General Electric.

C. Gould.

D. Marathon.

E. Regal-Beloit Corporation (Century).

F. Westinghouse

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Electrical Service: All motors shall be supplied in accordance with the following voltage and phase unless noted otherwise on the Drawings.

1. Motors less than 1/2 HP: 115 volts, single phase, 60 Hz.
2. Motors 1/2 HP and Larger: Voltage as scheduled, three phase, 60 Hz.

B. Construction:

1. Open drip-proof except where noted otherwise.
2. Design for continuous operation in 104 degrees F environment.
3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type. Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
4. Motors 3/4 HP and above: Energy Efficient Type.

5. Provide "Quiet" rating on motors located in occupied spaces of building.

C. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.

D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.

E. Wiring Terminations:

1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
2. For fractional horsepower motors where connection is made directly, provide flexible conduit connection in end frame. Maximum length of flexible conduit shall be five feet.

2.3 APPLICATIONS

A. Exception: Motors less than 250 Watts, for intermittent service may be the equipment manufacturer's standard and need not comply with these specifications.

B. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.

C. Single phase motors for fans, pumps, blowers and air compressors: Capacitor start type.

D. Single phase motors for fans less than 1 hp and greater than 1/12 hp: Electronically commutated type.

E. Motors located in exterior locations, air cooled condensers, humidifiers and explosion proof environments: Totally enclosed fan cooled type.

2.4 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque.

B. Starting Current: Up to six times full load current.

C. Multiple Speed: Through tapped windings.

D. Open Drip-proof: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.5 SINGLE PHASE POWER - CAPACITOR START MOTORS

A. Starting Torque: Three times full load torque.

B. Starting Current: Less than five times full load current.

C. Pull-up Torque: Up to 350 percent of full load torque.

D. Breakdown Torque: Approximately 250 percent of full load torque.

E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor minimum 1.35, prelubricated ball bearings.

G. Totally enclosed fan cooled Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.6 THREE PHASE POWER - SQUIRREL CAGE MOTORS

A. Starting Torque: Between 1 and 1-1/2 times full load torque.

B. Starting Current: Six times full load current.

C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics except Design C where required for high starting torque.

D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.

E. Insulation System: NEMA Class B or better.

F. Drip-proof Enclosure: NEMA Service Factor.

G. All motors controlled by variable frequency controllers shall have a 1.15 Service Factor.

H. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.

I. Motor Frames: NEMA 48 Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

J. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Division 26 - Motor Controlling Equipment.

K. Bearings: Grease lubricated anti-friction ball or roller bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 100,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Where belt or other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading.Stamp bearing sizes on nameplate.

L. Sound Power Levels: To NEMA MG 1.

M. All totally enclosed motors shall be fan cooled type. Non-ventilated type motors are not acceptable.

N. Motors controlled by variable frequency drives:

1. Rated for voltage peaks and minimum rise times in accordance with NEMA MG1, Part 31.
2. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
3. Inverter-Duty Motors: Class B temperature rise; Class F insulation.

4. Grounding: Provide shaft grounding system equal to AEGIS SGR Bearing Protection Ring, Inpro/Seal Current Diverter Ring (CDR) or approved equal. Install system in accordance with manufacturer's recommendations.
5. Motor Overload Relay: When a single drive is used to supply power to multiple motors, provide a solid state 3-phase adjustable overload relay between the drive and each motor.

    a. Relay shall have manual reset.
    b. Provide alarm contact with automatic reset overloads.

O. Part Winding Start, Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

P. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.

Q. Nominal Efficiency: Motors shall have minimum NEMA premium efficiency at full load and rated voltage when tested in accordance with IEEE 112.

R. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

2.7 ELECTRONICALLY COMMUTATED MOTORS (ECM)

A. Minimum efficiency: 70 percent when rated in accordance with NEMA Standard MG 1 at full load rating conditions.

B. Motor shall be permanently lubricated with heavy-duty ball bearings to match the equipment load and prewired to the specific voltage and phase.

C. Internal motor circuitry shall convert AC power supplied to the equipment to DC power to operate the motor.

D. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal.

2.8 CAPACITORS

A. Furnish capacitors for power factor correction as specified herein on motors furnished under Division 23 that are not connected to variable frequency drives. KVAR size shall be as required to correct motor power factor to 90 percent or better and shall be installed on all motors 1 horsepower and larger, that have an uncorrected power factor of less than 85 percent at rated load.

B. Features:

1. Individual unit cells.
2. All welded steel housing.
3. Each capacitor internally fused.
4. Non-flammable synthetic liquid impregnated.
5. Craft tissue insulation.
6. Aluminum foil electrodes.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install securely on firm foundation.

C. Check line voltage and phase and ensure agreement with nameplate.

D. Install motor overload relays in a common enclosure adjacent to the variable frequency drive

3.2 NEMA OPEN MOTOR SERVICE FACTOR SCHEDULE

HP	3600 RPM	1800 RPM	1200 RPM	900 RPM
1/6-1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1.5-150	1.15	1.15	1.15	1.15

3.3 PERFORMANCE SCHEDULE: THREE PHASE - OPEN DRIP-PROOF

HP	RPM(Sync)	NEMA Frame	Minimum Percent Efficiency	Minimum Power Factor
1	1200	145T	80	72
1-1/2	1200	182T	85	73
2	1200	184T	85.5	75
3	1200	213T	86.5	60
5	1200	215T	87.5	65
7-1/2	1200	254T	90	73
10	1200	256T	90.2	74
15	1200	284T	90.2	77
20	1200	286T	92	78
1	1800	143T	82.5	84
1-1/2	1800	145T	85	85
2	1800	145T	85	85
3	1800	182T	86.5	86
5	1800	184T	87.5	87
7-1/2	1800	213T	90	86
10	1800	215T	90	85
15	1800	256T	91	85
20	1800	256T	92	86
1-1/2	3600	143T	85	85
2	3600	145T	85	87
3	3600	145T	85	85
5	3600	182T	85.5	86
7-1/2	3600	184T	90	88
10	3600	213T	90	86

15	3600	215T	90	89
20	3600	254T	92	89
25	3600	256T	92	92

3.4 PERFORMANCE SCHEDULE: THREE PHASE-ENERGY EFFICIENT, TOTALLY ENCLOSED, FAN COOLED

HP	RPM(Sync)	NEMA Frame	Minimum Percent Efficiency	Minimum Power Factor
1	1200	145T	80	72
1-1/2	1200	182T	85.5	65
2	1200	184T	86.5	68
3	1200	213T	87.5	63
5	1200	215T	87.5	66
7-1/2	1200	254T	90	68
10	1200	256T	90	75
15	1200	284T	90.2	72
20	1200	286T	92	76
1	1800	143T	82.5	84
1-1/2	1800	145T	85	85
2	1800	145T	85	85
3	1800	182T	87.5	83
5	1800	184T	87.5	83
7-1/2	1800	213T	90	85
10	1800	215T	90	84
15	1800	254T	92	86
20	1800	256T	92	85
1-1/2	3600	143T	85	85
2	3600	145T	85	87
3	3600	182T	85.5	87
5	3600	184T	87.5	88
7-1/2	3600	213T	90	86
10	3600	215T	90	86
15	3600	254T	90.2	91
20	3600	256T	92	89
25	3600	284T	92	92

END OF SECTION

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Support and attachment components.

B. Horizontal piping hangers and supports.

C. Saddles and shields.

D. Vertical piping clamps.

E. Pre-engineered roof pipe supports.

F. Pre-engineered roof equipment supports.

G. Anchors and fasteners.

H. Miscellaneous materials.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

1.3 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each type of hanger and support. Include a hanger and support schedule showing manufacturer's figure number, size, location, and features for each hanger and support. Submit style and type to Structural Engineer for approval prior to installation.

B. Product Certificates: Signed by the manufacturer of hangers and supports certifying the products meet the specified requirements.

C. Maintenance Data: For inclusion in Operating and Maintenance manual specified in Division 01 and Division 23 Section "General Mechanical Requirements."

D. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution. Include dimensions, weights, required clearances, and method of assembly.

1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.

E. Installer's Qualifications: Include evidence of compliance with specified requirements.

F. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.4 QUALITY ASSURANCE

A. Comply with applicable building code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Flame/Smoke Ratings: Provide hangers and supports with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by UL 723 or ASTM E84 (NFPA 255) method.

D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

1.6 DEFINITIONS

A. Terminology used in this Section is defined in MSS SP-90.

PART 2 - PRODUCTS AND MATERIALS

1.1 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Comply with MSS SP-58.
2. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of work.

3. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
6. Materials: Products and materials listed in this specification are based on indoor, dry locations. Use corrosion resistant materials suitable for the environment where installed.

    a. Indoor Dry Locations: Provide painted carbon steel, galvanized steel or zinc-plated steel. Where supports will be field painted in exposed locations, provide carbon steel.
    a. Indoor Damp or Wet Locations: Galvanized steel or type 304 stainless steel.
    b. Outdoor Locations: Galvanized steel or Type 304 stainless steel.
    c. Dielectrics Barriers: Provide dielectric barriers between metallic supports and metallic piping and associated items of dissimilar type. Acceptable barriers include rubber, or copper-plated coatings where attachments are in direct contact with copper.
    d. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    e. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
    f. Stainless Steel: Type 304 or 316 in accordance with ASTM A240.

B. Metal Channel (Strut) Framing Systems:

1. Manufacturers:

    a. Cooper B-Line.
    b. Ferguson Enterprises/FNW.
    c. PHD Manufacturing.
    d. Thomas & Betts Corporation.
    e. Unistrut, a brand of Atkore International Inc.
    f. Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.

2. Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
3. Comply with MSS SP-58, Type 59, MSS SP-89, and . Welds shall comply with AWS D1.1.
4. Channel Material:

    a. Indoor Dry Locations: Provide carbon steel, galvanized steel or zinc-plated steel. Where supports will be field painted in exposed locations, provide carbon steel .
    b. Indoor Damp or Wet Locations: Galvanized steel or Type 304 stainless steel.
    c. Outdoor Locations: Galvanized steel or Type 304 stainless steel.
    d. Natatorium or other treated pool environments: Type 316 stainless steel.
    e. All nuts, brackets, and clamps shall have the same finish as the channel.

5. Minimum Channel Thickness: Steel sheet, 14 gage, 0.0747 inch.
6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height with factory-punched attachment holes.
7. Provide plastic galvanic isolators for connecting bare copper pipe for use with pre-engineered support strut system where indicated.

C. Hanger Rods:

1. Material:

a. Indoor Dry Locations: Zinc-plated steel.
b. Indoor Damp or Wet Locations or Outdoor Locations: Zinc-plated steel or type 304 stainless steel.
c. Natatorium or other treated pool environments: Type 316 stainless steel.

2. Threaded both ends or continuously threaded.
3. Minimum Size: Reference piping specification sections for rod thicknesses.
4. Threaded Rods: Threaded rods are not allowed for floor supports except when the maximum length of the rod is less than 12". Threaded rod sizes shall be the same size diameter as specified for pipe hanger rods based upon pipe size being supported. Refer to system piping specification sections for rod size requirements.

D. Wire Rope Pipe Hanging Systems:

1. Manufacturers:

a. ASC Engineered Solutions.
b. Gripple.

2. General: Wire rope hanger system shall have a minimum 5 to 1 safety factor based upon the applied working load being supported.
3. Source Limitations: Furnish associated fittings, accessories, and hardware produced by a single manufacturer.
4. Cast-in-place Concrete Insert: Pressed steel body with sintered steel wedge, 302 stainless steel spring and UV stabilized homopolymer polypropylene end cap. Model: Gripple Spider Hanging Kit.
5. Cable Stud: Carbon steel, zinc-coated, designed for attachment to concrete inserts. Model: ASC Engineered Solutions C120.
6. Cable Coupling: Carbon steel, zinc-coated, designed for attachment to threaded rods. Model: ASC Engineered Solutions C130.
7. Cable Eyelet: Carbon steel, zinc-coated, designed to be directly attached to structural supports via anchors or fasteners. Model: ASC Engineered Solutions C150.
8. Cable Toggle: Carbon steel, zinc-coated, with toggle designed for insertion into 1/2 inch hole through steel deck hat channel and provides anchor when pulled in tension. Model: ASC Engineered Solutions C160.
9. Swivel Toggle Insert: Single assembly attached to wire rope cable, manufactured from plated carbon steel toggle, pins, and shackles; swivel insert engineered to be compatible with concrete insert.
10. Wire Rope: High tensile steel wire rope, to ASTM A1023, Class A zinc coating; minimum 7 by 7 cross-sectional thread construction; having a tensile strength of 256,000 psi; No.3 wire size minimum.
11. Adjustable Fastener: Mild steel (type UG2), 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 500 lb. Model: Gripple No. 2, 3 or 4 UniGrip.

2.2 HORIZONTAL PIPING HANGERS AND SUPPORTS

A. Manufacturers:

1. Armacell.
2. ASC Engineered Solutions.
3. Cooper B-Line, Inc.
4. Elite Components.
5. ERICO/Michigan Hanger Co./Caddy
6. Ferguson/FNW.
7. Halfen-DEHA.
8. Hilti.
9. National Pipe Hanger Corporation.
10. PHD Manufacturing.
11. Power-Strut.
12. Unistrut.

B. Single Hangers:

1. Band Hanger: Carbon steel, adjustable band, adjustable swivel.
2. Split Ring: Carbon steel, adjustable swivel, split ring type.
3. Clevis Hanger: Carbon steel, adjustable, clevis type.
4. Roll Support Hanger: Adjustable steel yoke, cast iron roll.

C. Trapeze and Strut-mounted Supports:

1. Two-piece clamp: Designed for use with channel strut, held in place at channel shoulder when clamp attachment nut is tightened.
2. Roll Support: Adjustable cast iron roll attached to metal channel strut framing system with brackets and nuts.

D. Hangers and strut-mounted supports with pre-manufactured polymer inserts:

1. Manufacturers:

   a. ASC Engineered Solutions.
   b. Holdrite.
   c. Klo-Shure.

2. Strut-mounted pipe clamps and clevis hangers with pre-manufactured polymer inserts designed to receive butted insulation internally. Inserts shall support piping independent of insulation to avoid crushing. Installed system shall provide equal thermal and vapor barrier performance as systems with continuous unbroken insulation. Metal shields are not required with clevis hangers of this type.

E. Spring Hangers:

1. Reference Section "Vibration Isolation for HVAC Piping and Equipment" for spring isolation hangers.

F. Wall Supports:

1. Two-hole strap, galvanized steel or copper to suit pipe material. Provide rigid insulation between strap and pipe to maintain continuous insulation and vapor barrier where required.
2. Welded steel bracket reinforced with angle or strut. Support pipe from bracket using horizontal pipe hanger or support appropriate for the pipe type.

G. Pre-Insulated Supports:

1. Manufacturers:

   a. Aeroflex USA, Inc.
   b. Armacell.
   c. Buckaroos, Inc.
   d. Cooper B-Line, Inc.
   e. Pipe Shields, Inc.

2. General Construction and Requirements:

   a. Flexible elastomeric insulation with integral high-density pipe support insert shall conform to ASTM C534, Type I.
   b. Surface Burning Characteristics: Assembly shall have a flame spread index/smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.
   c. Waterproof calcium silicate insulation shall conform to ASTM C795.
   d. Rigid phenolic foam insulation shall conform to ASTM C1126, Type III.
   e. Insulation inserts shall be surrounded by a 360 degree jacket or shield.

3. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.

2.3 SADDLES AND SHIELDS

A. Pipe Covering Protection Saddles:

1. Manufacturers: Same as hanger and Supports.
2. Meet MSS SP-58 Type 39A or B, 100-psi average compressive strength, with center rib for pipes 12 inches and larger. Saddles shall cover approximately one sixth of the circumference of the pipe and shall be 12 inches long.

B. Insulation Protection Shield:

1. Sheet metal construction, meeting MSS SP-58 Type 40, of 18 gauge for 5-1/2 inches inside dimension and smaller.
2. Shield shall cover half of the circumference of the pipe and shall be of length indicated by manufacturer for pipe size and thickness of insulation.
3. Lengths for pipes greater than 2 inches: Minimum 8 inch long section at each support.
4. For pipes 2 inch and smaller without pre-insulated supports, provide insulation protection shields installed between hanger and pipe which meets the following minimum length requirements:

Pipe Size (NPS)	Insulation Thickness (inches)	Minimum Shield Length, (in) Hanger Spacing, (ft) 5	6	7	8	9	10
	0.5	5	6	8	-	-	-
	1	3	5	5	-	-	-
≤ 1	1.5	3	5	5	-	-	-
	2	3	3	3	-	-	-
	3	3	3	3	-	-	-
	0.5	8	8	11	11	12	14
	1	5	6	8	9	11	11
≤ 2	1.5	5	6	8	8	9	9
	2	5	5	6	6	8	8
	3	5	5	6	6	6	8

C. 360 Degree Insulation Protection Shield:

1. Shield shall cover all of the circumference of the pipe with two half circumference sections held together with bolts and nuts and shall be of length indicated by manufacturer for pipe size and thickness of insulation.

D. Plastic Saddles and Shields:

1. Manufacturers:

a. Armacell.
b. Eaton.
c. Hydra-Zorb.
d. PHD Manufacturing.
e. Zsi Foster.

2. Polymer-based, snap-on or clip-on design, with non-adhesive surface and lip to allow lateral movement of piping without damaging insulation, field-paintable.

2.4 VERTICAL-PIPING SUPPORTS

A. Manufacturers:

1. ASC Engineered Solutions.
2. Cooper B-Line, Inc.
3. Halfen-DEHA.
4. Hilti.
5. ERICO/Michigan Hanger Co.
6. National Pipe Hanger Corporation.
7. PHD Manufacturing.
8. Power-Strut.
9. Unistrut.

B. Components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have factory applied or field-applied finish.
2. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
3. Components as listed below shall be made of 304 stainless steel where installed in corrosive environments and/or where indicated on the drawings.

C. Riser Clamps with pre-manufactured polymer insert:

1. Manufacturers:

a. Hydra-Zorb; Titan Riser Clamp.
b. National Pipe Hanger.
c. Pipe Hangers, Inc.

2. Riser clamp with pre-manufactured polymer inserts designed to withstand vertical loading and receive butted insulation internally. Inserts shall support piping independent of

insulation to avoid crushing. Installed system shall provide equal thermal and vapor barrier performance as systems with continuous unbroken insulation.

2.5 PRE-ENGINEERED ROOF PIPE SUPPORTS

A. Manufacturers:

1. Airtec.
2. ASC Engineered Solutions.
3. Cooper B-Line, Inc.
4. Elite Components.
5. ERICO/Michigan Hanger Co./Caddy.
6. Ferguson/FNW.
7. Miro.
8. PHP Systems/Design.
9. PHD Manufacturing.
10. Roof Top Blox.
11. Unistrut, a brand of Atkore International Inc.
12. Zsi Foster.

B. General: Pre-engineered devices with embedded pipe support fixtures as specified.

C. Pedestals: Steel pedestals with thermoplastic or rubber base with the following dimensions:

1. Up to 12 inch strut length support: 18 inch x 18 inch.
2. Up to 16 inch strut length support: 24 inch x 18 inch.
3. Up to 24 inch strut length support: 30 inch x 18 inch.
4. Thickness: Minimum 3/16 inch thick.

D. Block Bases: Closed-cell polyethylene blocks with the following dimensions.

1. Length: Nominal 10 inch, 12 inch, 16 inch, or 24 inch
2. Width: Nominal 4 inches.

E. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.

F. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.

2.6 PRE-ENGINEERED ROOF EQUIPMENT SUPPORTS

A. Reference Section "Vibration Isolation for HVAC" for vibration isolated pre-engineered roof equipment supports.

B. Manufacturers: Subject to compliance with requirements, provide roof equipment supports from the equipment manufacturer or from one of the following:

1. AES Industries.
2. Custom Curb, Inc.
3. Pate Company.
4. Thybar.

C. Single Rail Equipment Supports:

1. Construction:

a. Base plate with fully mitered raised cant and step to match roof insulation thickness.
b. Welded, minimum 18 gauge galvanized steel shell, internally reinforced to load bearing factors of equipment being supported.
c. Factory installed treated wood nailer.
d. 4 inch, minimum 18 gauge nailer jacket with counterflashing where equipment will not fully cover the equipment support.

D. Roof Curbs:

1. Construction:

a. Comply with NRCA standards.
b. Base plate with fully mitered raised cant and step to match roof insulation thickness.
c. Welded, minimum 18 gauge galvanized steel shell, internally reinforced to load bearing factors of equipment being supported.
d. Minimum 1-1/2 inch thick, 3 pound density rigid insulation internal to shell to maintain continuous roof insulation.
e. Factory installed treated wood nailer and drain nipple.
f. Sloped to match roof structure to enable level installation.

2.7 ANCHORS AND FASTENERS

A. Manufacturers:

1. Hilti, Inc.
2. Illinois Tool Works, Inc.
3. Phillips.
4. Powers Fasteners, Inc.
5. Rawl.
6. Simpson Strong-Tie Company Inc.

B. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

1. Concrete: Use preset concrete inserts or expansion anchors.
2. Solid or Grout-Filled Masonry: Use expansion anchors.
3. Hollow Masonry: Use toggle bolts.
4. Hollow Stud Walls: Use toggle bolts.
5. Steel: Use beam clamps.
6. Sheet Metal: Use sheet metal screws.
7. Wood: Use wood screws.
8. Plastic and lead anchors are not permitted.
9. Hammer-driven anchors and fasteners are permitted only as follows:

a. Nails are permitted for attachment of nonmetallic boxes to wood frame construction.
b. Staples are permitted for attachment of nonmetallic-sheathed cable to wood frame construction.

C. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.

1. Comply with MFMA-4.
2. Channel Material: Use galvanized steel.
3. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch minimum base metal thickness.
4. Spot Inserts: Carbon steel with zinc plating or galvanized steel body and base plate, with protective sleeve for anchor rod insert, sized to accommodate anchor rode dimensions.
5. Manufacturers:

    a. Same as manufacturer of metal channel (strut) framing system.
    b. DeWalt "Bang-It" concrete inserts.

D. Post-Installed Concrete and Masonry Expansion Anchors:

1. Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.
2. Self-drilling, drilled flush or shell type. Size inserts to suit threaded rods.

E. Beam Clamps: MSS SP-58 C-Type or adjustable, Types 19 through 23, 25 or 27 through 30 based on required load.

1. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
1. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.

F. Vibration Isolation Anchors: Reference Section "Vibration Isolation for HVAC Piping and Equipment" for vibration isolation anchors.

2.8 MISCELLANEOUS MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36.

B. Malleable Iron: ASTM A47

C. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION, GENERAL

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

B. Provide hangers and supports according to the Pipe Hanger and Support Schedule below.

C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.

D. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.

E. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.

F. Unless specifically indicated or approved by Architect, do not provide support from roof deck.

G. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

H. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.

I. Provide vibration isolators at hangers and supports where specified in Section "Vibration Isolation for HVAC".

3.3 INSTALLATION OF HANGERS AND SUPPORTS

A. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58 unless indicated otherwise.

B. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.

C. Space attachments within maximum piping span length specified in Division 23 piping sections.

D. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

E. Install hangers, supports, clamps and attachments to support piping properly from building structure.

F. Do not attach to ceilings, equipment, ductwork, conduit and other non-structural elements such as floor and roof decking.

G. Hanger and clamps sizing:

1. Cold Piping: Provide pipe hangers sized for the pipe outside diameter plus insulation thickness.
2. Hot Piping: Provide pipe hangers sized for the pipe outside diameter plus insulation thickness.
3. Vertical Piping: Provide clamps sized for the pipe outside diameter and extend clamp through insulation.
4. Refer to Section "HVAC Insulation" for definition of hot and cold piping and required insulation thickness.

H. Where several pipes can be installed in parallel and at the same elevation, Contractor has option to provide metal channel strut framing. Install supports with maximum spacing specified within Division 23 piping sections.

1. Space strut framing at the required distance for the smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.
2. Where strut systems are attached to walls, install anchor bolts per manufacturer's recommendations.

a. Uninsulated Copper Pipe: Install with plastic galvanic isolators
b. Insulated Tube or Pipe: Install with 360° insulation protection shields or pre-engineered thermal hanger-shield inserts as specified in Section "HVAC Insulation".

I. Install building attachments within concrete or to structural steel.

1. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping as specified in Division 23 piping sections.
2. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2,500 psi is indicated, install reinforcing bars through openings at top of inserts.

J. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Provide two nuts on threaded supports to securely fasten the support.

K. Install appropriate types of hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

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

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ASME B31.9 Building Services Piping Code is not exceeded.

N. Insulated Piping: Comply with the following installation requirements.

1. Riser Clamps: Attach riser clamp to piping with riser clamps projecting through insulation. Do not use riser clamps to support horizontal, insulated piping. Seal insulation for hot piping and protect vapor barrier for cold piping as specified in Division 23 Section "HVAC Insulation".

a. Contractor's Option: Provide riser clamps with pre-manufactured polymer insert.

2. Pipe Covering Protection Saddles: Install pipe covering protection saddles where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation.

a. If insulation protection shields are used instead of protection saddles on hot piping where vapor barrier is not required, provide high density insulation insert sized for the insulation thickness used as specified in Division 23 Section "HVAC Insulation".

3. Insulation Protection Shield: Install insulation protection shield with high density insulation insert, sized for the insulation thickness used as specified in Division 23 Section "HVAC Insulation". Do not use polymer-based shields for hot piping.

a. Exception for 2 inch and smaller horizontal piping with cellular glass, flexible elastomeric, or polyisocyanurate insulation: High density insulation insert is not required. Provide insulation protection shield over the insulation with length specified for pipe size and insulation thickness to prevent puncture or other damage.

4. Contractor's Option: Provide pre-engineered thermal hanger inserts for piping insulated with flexible elastomeric insulation at pipe supports for piping 2-1/2 inches and larger.
5. Contractor's Option: Provide strut-mounted pipe clamps and clevis hangers with pre-manufactured polymer inserts.

O. Strut Framing Systems: Channel strut systems can be used at the Contractors option in lieu of individual hangers for horizontal pipes. Arrange for grouping of parallel runs of horizontal piping. Space channel strut systems at the required distance for the smallest pipe supported. Provide channel gauge and hanger rods per the manufacturer's recommendations for the piping supported. Where strut systems are attached to walls, install anchor bolts per manufacturer's recommendations.

1. Uninsulated Copper Pipe: Install with plastic galvanic isolators
2. Insulated Tube or Pipe: Install with 360 degree insulation protection shields or pre-engineered thermal hanger-shield inserts as specified in Division 23 Section "HVAC Insulation".

P. Vertical Piping Risers:

1. Reference Section "Vibration Isolation for HVAC Piping and Equipment" for piping riser supports.

Q. Wire Rope Hanging Systems:

1. Install in accordance with manufacturer's instructions.
2. Supported load shall not exceed manufacturer's recommended load rating.
3. Applications for Pipe Supports:

a. 3 inch and smaller.
b. Wire rope hanging system is not allowed for steam or steam condensate piping.

4. Do not support pipe by wrapping the rope around the pipe.
5. Provide appropriate hanger or support compatible with the wire rope hanging system adjustable fastener as specified in the Pipe Hanger and Support Schedule.
6. Install cast-in-place concrete inserts in elevated concrete slabs.
7. Install bream clamps for attachment to structural beams as required.

3.4 INSTALLATION OF PRE-ENGINEERED ROOF PIPE SUPPORTS

A. Install pre-engineered roof pipe supports anchored to the roof structure.

1. Install supports to meet the specified design criteria.

a. Building Design Risk Category: II.
b. Design Wind Speed: 100 mph.

2. Coordinate with the pre-engineered roof pipe support manufacturer to anchor the pipe supports directly to the roof structure in accordance with the manufacturer's installation instructions or provide intermediate pipe supports engineered to meet the design criteria.

3. Submit design and installation requirements as a Deferred Submittal.

3.5 INSTALLATION OF ROOF EQUIPMENT SUPPORTS

A. Attach roof equipment support to the roof structure according to the manufacturer's installation instructions.

B. Provide multiple single rail equipment supports to uniformly support the equipment.

C. Provide rigid backing material (e.g., insulation, wood, etc.) to maintain cant slope.

D. Install supports to maintain continuous insulation on roof.

E. Provide vibration isolators between roof equipment support and equipment according to Division 23 Section "Vibration Isolation for HVAC."

F. If vibration isolation is not required or units are internally isolated, attach equipment directly to pre-engineered roof equipment support using one of the following:

1. Single Rail Equipment Supports: Secure each equipment support leg to the rail with a minimum of 4 points of connection per leg.
2. Roof Curbs:

    a. Secure each corner of the equipment to the curb nailer using a minimum of 4 lag screws, located along the length of the equipment.
    b. Secure equipment to the curb using hold-down brackets. Provide minimum 6 inch long, 14 gauge galvanized steel brackets sized to wrap around top of curb and under equipment base rail with sufficient horizontal offset to cover overlap gap between the equipment rail and curb. Secure bracket to equipment and curb nailer using a minimum of 8 points of connection per bracket. Provide one bracket at each corner along the length of the unit.

3.6 EQUIPMENT SUPPORT AND ATTACHMENT

A. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.

B. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls.

C. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.

D. Preset Concrete Inserts and Expansion Anchors: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.

1. Where concrete slabs form finished ceiling, locate anchors flush with slab surface.

E. Secure fasteners according to manufacturer's recommended torque settings.

F. Remove temporary supports.

G. Fabricate structural steel supports to suspend equipment from structure above or support equipment from floor.

H. Grouting: Place grout under supports for piping and equipment.

3.7 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

3.8 FIELD QUALITY CONTROL

A. Examine support and attachment components for damage and defects.

B. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

D. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces. Comply with Division 09 Section "Painting."

1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

E. For galvanized surfaces clean welds, bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

F. Correct deficiencies and replace damaged or defective support and attachment components.

3.9 PIPE HANGER AND SUPPORT SCHEDULE

A. Additional hanger and support requirements are in Sections specifying piping systems and equipment.

B. Provide the following acceptable hangers and supports for each type of piping system. Hangers and supports may be single type or strut-mounted:

C. Single Hangers:

1. All pipe sizes 1-1/2 inch and less:

a. Band hanger.
b. Swivel split ring.
c. Clevis hanger.

2. Cold and Hot pipe sizes 2 inches and greater where pipes are in stationary position: Clevis hanger.
3. Cold and Hot pipe sizes 2 inches and greater for pipes in the following locations: Roll support hanger.

    a. Axial movement due to thermal expansion or contraction generates swing angles in excess of 4 degrees.
    b. Between anchor locations shown on the drawings.

D. Trapezes and Strut-mounted Supports:

1. Pipes in stationary position: Two-piece clamp, strut clamp or U-bolts.
2. Cold and Hot pipe sizes 2 inches and greater in the following locations: Roll support.

    a. Axial movement due to thermal expansion or contraction generates swing angles in excess of 4 degrees.
    b. Between anchor locations shown on the drawings.

E. Wall Supports:

1. Pipe sizes 3 inches and less:

    a. Two-hole strap mounted to wall.
    b. Welded steel bracket with reinforced angle or strut.

2. Pipe sizes 4 inch and greater:

    a. U-bolt.
    b. Welded steel bracket with reinforced angle or strut.

F. Floor Supports:

1. Pipes in stationary position: Pipe saddle.
2. Cold and Hot pipe sizes 2 inches and greater in the following locations: Roll support.

    a. Axial movement due to thermal expansion or contraction is greater than one inch.
    b. Between anchor locations shown on the drawings.

END OF SECTION 230529

SECTION 230550 - VIBRATION ISOLATION FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration isolation requirements.

B. Vibration isolators.

1.2 COORDINATION

A. Contractor's Responsibility:

1. Verify the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this specification. Any additional equipment needed to meet the intent of this specification, even if not specifically mentioned herein or in the Contract Documents, shall be supplied by the Contractor without claim for additional payment.
2. Performance or waiving of inspection, testing or surveillance for any portion of the Work shall not relieve the Contractor of the responsibility to conform strictly with the Contract Documents. The Contractor shall not construe performance or waiving of inspection, testing or surveillance by the Owner or Architects to relieve the Contractor from total responsibility to perform in strict accordance with the Contract Documents.
3. Coordinate selection and arrangement of vibration isolation components with the actual equipment to be installed.
4. Coordinate the work with other trades to provide additional framing and materials required for installation.
5. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
6. Sequencing:

    a. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

B. Manufacturer's Responsibility:

1. Determine vibration isolation types for all equipment and systems in accordance with the local governing code.
2. Calculate the static deflection requirements for all equipment and systems to provide uniform deflection based on distributed operating weight of actual installed equipment.
3. Select the vibration isolation systems to provide static deflection indicated on the Vibration Isolation Schedule and as specified below. Determine the mounting sizes and layout.
4. Guarantee specified isolation system deflection.
5. Select and size vibration isolators to not exceed the recommended loading of the isolators.
6. Provide installation instructions, drawings and field supervision to ensure proper installation and performance.
7. Verify that all equipment to be isolated has sufficient support structure to distribute equipment loads onto isolators.

1.3 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.

1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification method for spring element load capacities. Include clearly outlined procedures for installing and adjusting the isolators.

B. Shop Drawings:

1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators on each piece of isolated equipment. Indicate equipment weights and static deflections.

C. Vibration Isolation System Schedule: Include the following for each isolation element:

1. Manufacturer, isolator type, model number, size.
2. Height when uncompressed and static deflection.
3. Spring constant.
4. Spring outside diameter, free operating, and solid heights.
5. Design of supplementary bases.
6. Details of attachment to load-bearing structure or supplementary framing.

D. Post-Installation Inspection Report:

1. Vibration isolation vendor notice of inspection of all vibration isolators.
2. Vibration isolation vendor notice of approval that all vibration isolators have been properly installed and conform to the specification.
3. Itemized list of deficiencies.
4. Vibration Isolation System Schedule.
5. For each isolator containing steel springs, record the following:

a. Size.
b. Uncompressed height.
c. Design static deflection.
d. Measured static deflection.

1.4 QUALITY ASSURANCE

A. All vibration isolation equipment shall be furnished by one manufacturer unless specifically approved otherwise in writing by the Engineer.

B. All vibration isolation equipment and materials shall be new and manufactured specifically for the purpose intended.

C. Maintain at the project site a copy of each reference document that prescribes execution requirements.

D. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Caldyn, California Dynamics Corp.

B. Kinetics Noise Control.

C. Mason Industries, Inc.

D. Thybar Corporation.

E. Vibration Eliminator Co., Inc.

F. Vibration Mounting and Controls.

G. Vibro-Acoustics.

2.2 VIBRATION ISOLATION REQUIREMENTS

A. Construct vibration isolators out of resilient materials resistant to oil, ozone, and oxidant.

B. Select vibration isolators to provide the static deflection as specified in Part 2 "Products" unless otherwise specified for the application listed in Part 3 "Execution."

C. Vibration isolators shall have either known undeflected heights or calibration markings so that the amount of deflection can be verified after adjustment to determine that the load is within the proper range of the device and that the correct degree of vibration isolation is provided according to the design.

D. Vibration isolators, base frames, and inertia bases shall provide uniform deflection and stability under all operating loads.

E. Isolators for fans shall be sized so that thrust restraints (which would act against turning moment caused by static pressure) are not required.

F. Lateral restraining isolators shall have the same static deflection as the vertical isolators for the equipment being isolated.

G. The theoretical vertical natural frequency for each support point based upon load per isolator and isolator stiffness shall not differ from the design objectives for the equipment as a whole by more than plus/minus 10 percent.

H. All elastomeric mountings shall have a Shore hardness of 30 to 60 plus/minus 5 after minimum aging of 20 days or corresponding over-aging, or as specified herein.

I. Elastomeric isolators that will be exposed to temperatures below 32 degrees F shall be fabricated of natural rubber instead of neoprene.

J. Vibration Isolator Assemblies with Steel Springs:

1. Housed or caged spring isolators are not acceptable.
2. Assemblies shall use bare springs, color coded or otherwise identify springs to indicate load capacity.
3. Spring diameter shall not be less than 0.8 of the loaded operating height of the spring.
4. The ratio of the horizontal to vertical spring constant shall be between 1 and 2.
5. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.
6. Assembly shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation.
7. Springs shall operate in the linear portion of their load versus deflection curve over a deflection range of not less than 50 percent above the design deflection.

K. Vibration isolators exposed to weather and other corrosive environments shall be protected with factory corrosion resistance.

1. Exterior applications:

a. Springs: Cadmium-plated and neoprene coated.
b. Nuts and bolts: Cadmium plated.
c. Other metal mounting parts: Hot-dip galvanized.

2. Interior applications: Painted.

2.3 VIBRATION ISOLATED EQUIPMENT SUPPORT BASES

A. Pre-Engineered Roof Equipment Support (Type RES):

1. Reference Section "Hangers and Supports for HVAC Piping and Equipment" for specification of non-vibration isolated, pre-engineered roof equipment supports.

B. Structural Rails (Type SR):

1. Assembly: Structural steel channels furnished with double-deflection neoprene mountings or spring isolators.
2. Base: All metal mounting parts shall be covered with neoprene to avoid corrosion and metal-to-metal contact.
3. Selection: Channel length and isolator type with deflection as required for proper isolation of equipment.
4. Type SR: Mason Industries Type RND or approved equal.

2.4 VIBRATION ISOLATORS

A. Ribbed Neoprene "Waffle" Pads (Type WP):

1. Assembly: Single ribbed or crossed double ribbed elastomer in-shear pads, in one or more layers separated and bonded to a minimum 1/4 inch thick galvanized steel shim plate as required to provide selected deflection.
2. Thickness: Each layer 5/16 inch thick.

3. Selection: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.05 inches.
4. Type WP: Mason Industries Type W, Type WSW, or approved equal.

B. Double Deflecting Neoprene Mounts (Type DDNM):

1. Assembly: Laterally stable, double deflecting, neoprene encapsulated mount with bolt holes for attachment to supporting structure.
2. Selection: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.4 inches unless specified otherwise.
3. Type DDNM: Mason Industries Type ND or approved equal.

C. Constrained Steel Spring Neoprene Mounts (Type CSNM):

1. Assembly: Single or multiple free-standing and laterally stable steel springs assembled into a factory-fabricated housing with integral leveling device and stops to limit vertical movement of the isolated equipment during a temporary weight reduction. Include rigid blocking to support equipment during rigging to maintain identical installed and operating heights of the isolator. Housing shall maintain a minimum clearance of 1 inch around restraining bolts and the spring so as not to interfere with the spring operation.

    a. Leveling Device: Rigidly connected to equipment or frame. Limit stops shall provide minimum 1/4 inch clearance between housing and isolator base plate under normal operation.
    b. Equipment Wind Loading Applications: Provide tapped hole in top and bottom plates for bolting to equipment and the roof or supporting structure with a neoprene mounting sleeve.

2. Base: Minimum 1/4 inch thick neoprene pad under housing.
3. Selection: Minimum static deflection of 2 inches unless specified otherwise.
4. Type CSNM: Mason Industries Type SLR or approved equal.

D. Neoprene Bushing (Type NR):

1. Assembly: Neoprene restraint, rubber-in-shear bushings for lightweight, suspended equipment supported from structure with all-thread rod and angle iron or Unistrut.
2. Selection: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.15 inches.
3. Type NR: Mason Industries Type HMIB or approved equal.

E. Spring and Neoprene Hanger (Type SPNH)

1. Assembly: Steel hanger box containing a laterally stable, double deflecting, neoprene isolator in series with a steel spring.

    a. Housing: Include a neoprene bushing to prevent contact between the lower hanger rod and hanger box and short-circuiting the isolating function. Bottom opening sized to allow hanger rod to swing through a 30 degree arc.

2. Selection:

    a. Neoprene isolator: Maximum durometer of 50 and designed for 15 percent strain, static deflection of 0.4 inches unless specified otherwise.
    b. Spring isolator: Minimum static deflection of 2 inches unless specified otherwise.

3. Type SPNH: Mason Industries Type 30N or approved equal.

F. Neoprene Mounting Sleeves, Grommets, and Bushings: Designed to prevent steel-to-steel contact within vibration isolators.

G. Flexible Connectors:
1. Duct: Refer to Section "Air Duct Accessories."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that mounting surfaces are ready to receive vibration isolation and associated attachments.

3.2 INSTALLATION - GENERAL

A. Install in accordance with manufacturer's instructions.

B. External spring isolators are not required if unit is provided with internal spring isolation. If external spring isolators are provided, internal spring isolation shall not be approved.

C. Mount or suspend all equipment, piping, ductwork, etc. from approved foundations and supports as specified herein or as shown on the drawings.

D. Secure fasteners according to manufacturer's recommended torque settings.

E. Support piping, ductwork, conduit, and mechanical equipment from the building structure. Do not support from other equipment, piping, or ductwork.

F. Install isolators to prevent short-circuiting of the isolation.

G. All wiring connections to mechanical equipment on isolators shall have a minimum 18 inch long flexible conduit in a "U" shaped loop. Coordinate with Division 26.

H. Flexible Connectors: Install flexible connectors sized to match equipment connections and to provide sufficient slack for vibration isolation as required.

I. Equipment connected to water or other fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping. Block-up equipment with temporary shims to final operating height. When the system is assembled full load is applied, adjust the isolators shall be adjusted to allow shim removal.

J. Refer to Division 23 Section "Common Work Results for HVAC" for noise critical spaces.

3.3 INSTALLATION OF VIBRATION ISOLATORS

A. Neoprene Mounting Sleeves, Grommets, and Bushings: Install on vibration isolators to prevent any metal to metal contact.

B. Spring Isolators:

1. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
2. Install springs so that the ends of springs remain parallel and all springs are installed with adjustment bolts.
3. Locate isolation hangers at the top of hanger rods.
4. Type SPNH and DDNH: Install the hanger box to allow it to rotate a full 360 degrees without encountering any obstruction.

3.4 EQUIPMENT ISOLATION

A. Fan Coil Units and Computer Room Units:
   1. Suspended: Flexible duct connectors with Type SPNH with 1 inch static deflection.

B. Fans
   1. Suspended:
      a. Fans 1 hp and less: Type NR isolation with 0.15 inch static deflection.
   2. Roof-mounted:
      a. Curb mounting: Type RES curb base, with closed cell sponge gasket for sealing, continuous along support sealed to curb top rail.

C. Pneumatic Air Compressors and Vacuum Pumps
   1. Slab-on-Grade 10 hp and greater: Housekeeping pad under Type CIB base, Type SPNM isolation with 1 inch static deflection.
   2. Suspended Slab: Housekeeping pad under Type CIB base, Type SPNM isolation with 2 inch static deflection.

D. Unit Heaters: Type SPNH isolation with 2 inch static deflection.

E. All other equipment not specifically identified in this specification that contains rotating or vibrating elements and any associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or RNM neoprene isolators as appropriate.

3.5 DUCT ISOLATION

A. Connect ducts to equipment, fans, fan casings, and fan plenums with flexible connectors.

3.6 FIELD QUALITY CONTROL

A. Arrange for inspection of all isolation and noise control equipment by the vibration isolation vendor and submit post-installation inspection report.

B. The installation of all vibration isolation systems shall be under the supervision of the manufacturer's representative.

C. Guarantee: If, in the actual installation, any equipment fails to meet the vibration control requirements specified herein, that equipment shall be corrected or replaced without claim for additional payment, inclusive of all labor and material costs. Such corrective measures shall be done within a time schedule specified by the Owner.

END OF SECTION

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Adhesive-backed duct markers.

D. Pipe markers.

E. Ceiling markers.

F. Engraved plastic-laminate signs.

1.2 CODES AND STANDARDS

A. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

B.

1.3 SUBMITTALS

A. Custom Signage: Submit list of wording, symbols, letter size, and color coding for mechanical identification. Terminology shall exactly match contract documents and shall be approved by Engineer prior to fabrication. Submit list of equipment to be provided with ceiling markers.

B. Product Data: Submit manufacturer's technical product data for each product required.

C. Manufacturer’s Installation Instructions: Indicate special procedures and installation for each product required.

1.4 SPARE PARTS

A. Furnish minimum of 5 percent extra stock of each mechanical identification material required for each system that uses the identification material.

PART 2 - PRODUCTS AND MATERIALS

2.1 ACCEPTABLE MANUFACTURERS

A. Allen Systems, Inc.

B. W.H. Brady Corporation.

C. Brimar Industries, Inc.

D. Seton Identification Products, a Tricor Direct Company..

2.2 IDENTIFICATION APPLICATIONS AND REQUIREMENTS

A. General:

1. Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections. Where more than a single type is specified for application, selection is the installer's option, but provide single selection for each product category.
2. Lettering: Coordinate names, abbreviations, and other designations used in mechanical identification work with the corresponding designations shown on the drawings, scheduled, and specified. If not otherwise indicated, provide numbering, lettering, and wording as recommended by the manufacturer or as required for proper identification, operation, and maintenance of mechanical systems and equipment.
3. Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (e.g., Boiler No. 3, Air Supply No. 1H, etc.).

B. Air Handling Units: Nameplates or engraved plastic laminate signs.

C. Automatic Controls: Tags, use the same naming convention coordinated with the building automation system.

D. Control Panels: Nameplates.

E. Dampers: Ceiling markers where located above lay-in ceiling. Do not use ceiling tacks in a gyp ceiling.

F. Ductwork: Adhesive-backed duct markers.

G. Fans: Nameplates, stencils, or engraved plastic laminate signs.

H. Instrumentation: Tags.

I. Major Control Components including Variable Frequency Drives: Nameplates or engraved plastic laminate signs.

J. Piping: Pipe Markers.

K. Relays: Tags.

L. Small-sized Equipment: Tags.

M. .

N. Thermostats: Nameplates.

O. General Signs: Engraved plastic laminate signs.

2.3 NAMEPLATES

A. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and mark number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

B. Size: 2-1/2 inch x 4 inch for control panels and components, 4-1/2 inch x 6 inch for equipment.

C. Letter Color: White.

D. Letter Height: 1/4 inch.

E. Background Color:

1. Cooling equipment: Green.
2. Heating equipment: Yellow.
3. Combination cooling and heating equipment: Yellow/Green.
4. Energy reclamation equipment: Brown.
5. Equipment and components that do not meet any of the above criteria: Blue.

F. Plastic: Conform to ASTM D709.

2.4 TAGS

A. Plastic Laminate Tags: Laminated three-layer plastic, minimum 3/32 inch thick, with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter and 5/32 inch hole for fastener.

B. Metal Tags: Provide 19-gauge polished brass with stamped letters. Tag size minimum 1-1/2 inch diameter with smooth edges and 5/32 inch hole for fastener. Fill tag engraving with black enamel paint.

C. Accident Prevention Tags: Pre-printed or partially pre-printed, of plasticized card stock with matte finish suitable for writing, minimum 3-1/4 inch x 5-5/8 inch size, with brass grommet in hole for fastener. Order with appropriate pre-printed wording (e.g., DANGER, CAUTION, DO NOT OPERATE, etc.).

D. Letter Height:

1. System Abbreviation: Minimum 1/4 inch.
2. Valve Number: Minimum 1/2 inch.

2.5 ADHESIVE-BACKED DUCT MARKERS

A. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.

B. Style: Individual label.

C. Nomenclature: Include air handling unit identification number, duct size, service, and arrows indicating direction of flow.

D. Specialty Exhaust: Identify the specialty using the system terminology (e.g., Grease, Dishwasher, Dryer, Fume Hood, etc.).

E. Color: Yellow background with black lettering or blue background with white lettering.

1. Hazardous Exhaust: Use colors and designs recommended by ASME A13.1.

2.6 PIPE MARKERS

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1

B. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1. Each end of the marker shall be secured to the pipe with one complete wrapping of pressure-sensitive tape.

C. Semi-rigid Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings, minimum 3 mil thick.

1. Width: 1-1/2 inch for pipes less than 6 inches (including insulation), 2-1/2 inch for pipes 6 inches and larger (including insulation).
2. Color shall match color of pipe markers.

E. Pipe Marker with Insulation: 1 inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F or greater. Insulation shall extend 2 inches beyond each end of plastic pipe marker.

F. Weather resistance: Where pipe markers shall be exposed to the weather, provide products suitable for use in weather.

G. Nomenclature: Manufacturer's standard pre-printed nomenclature which best describes piping system. Differentiate between supply and return. In the case of a variance, provide nomenclature as approved by the Engineer.

H. Arrows: Provide pipe markers with integral arrows indicating direction of flow or as a separate unit of plastic, or printed on pressure sensitive tape.

I. Color:

1. Conform to .
2. Heating, Cooling, and Boiler Feedwater: Green with white letters.
3. Compressed Air: Blue with white letters.

J. Letter Height: Minimum 1/2 inch for pipes up to 3 inch, minimum 1 inch for larger pipes.

2.7 CEILING MARKERS

A. Description: Paper dot, self-adhesive with 3/4 inch diameter color coded head.

B. Color:

1. HVAC Equipment: Yellow.
2. Fire Dampers and Smoke Dampers: Red.

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Engraving stock melamine plastic laminate complying with Fed. Spec L-P-387, engraved with manufacturer's standard letter style, black with white core letter color except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/16 inch thick for units up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger units.

C. Size: 1-1/2" high for single line, 2" high for two lines.

D. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

E. Nomenclature: When used to identify equipment, match terminology on schedules, including the following:

1. Name and mark number.
2. Equipment service.
3. Design capacity.

F. Access Panel Markers: Laminated three-layer plastic, minimum 1/16 inch thick and 1/8 inch hole for fastener, with abbreviations and numbers corresponding to concealed valve.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Division 09 for stencil painting.

3.2 GENERAL INSTALLATION

A. Coordination: 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. Install products in accordance with manufacturer's instructions.

C. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

D. Install in clear view and align with axis of piping.

E. Identify service, flow direction, and pressure.

F. All identification signs and markers shall be easily visible and legible. Relocate signs or markers that become visually blocked by work of others.

3.3 PIPING IDENTIFICATION

A. General: Provide pipe markers and flow arrows of one of the types specified for all systems. Provide only one type of marker for all systems. Install identification on the most obviously visible portion of the pipe from the point of access.

B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

C. Pipes less than 6 inches diameter (including insulation):, Provide full-band pipe markers with 360 degree coverage.

D. Location: Install piping identification where piping is exposed to view, concealed by a removable ceiling system, located in accessible maintenance spaces (shafts, tunnels, plenums, etc.) and exterior non-concealed locations as follows:

1. Within 5 feet of each valve, tee, and control device.
2. Within 5 feet of each branch, excluding branches less than 25 feet in length to fixtures or terminal heating and cooling units.
3. Within 5 feet of each side of a penetration of a wall, floor, ceiling, structure, or enclosure.
4. At access doors, manholes and similar access points which permit view of concealed piping.
5. Within 5 feet of equipment outlets and other points of origination and termination.
6. Spaced intermediately at a maximum spacing of 50 feet along each riser and run. Reduce spacing to 25 feet in congested areas where there are more than two piping systems or pieces of equipment.
7. On piping above removable acoustical ceilings.

3.4 DUCTWORK IDENTIFICATION

A. Install identification on the most obviously visible portion of the duct from the point of access.

B. Location: Install ductwork identification where ductwork is exposed to view, concealed by a removable ceiling system, located in accessible maintenance spaces (shafts, tunnels, plenums, etc), and exterior non-concealed locations as follows:

1. Within 5 feet of each control damper or balancing damper, excluding balancing dampers installed in duct take-offs to individual grilles, registers, or diffusers that are less than 25 feet in lengths and installed in the same space as the air device.
2. Within 5 feet of each branch duct, excluding branch ducts that are less than 25 feet in length and located in the same space as the main duct.
3. Within 5 feet of each side of a penetration of a wall, floor, ceiling, structure, or enclosure.
4. Spaced intermittently at a maximum spacing of 50 feet along each duct run. Reduce spacing to 25 feet in congested areas when there are more than two types of duct systems or pieces of equipment.
5. Within 5 feet of equipment outlets and other points of origin or termination.
6. Install marker on the most obviously visible portion of the duct from point of access.

3.5 ACCESS DOOR IDENTIFICATION

A. Provide identification on each access door, indicating purpose of access, maintenance and operating instructions, and appropriate safety and procedural information.

B. Where access doors are concealed above a removeable ceiling system or similar concealment, tags may be used in lieu of specified identification.

3.6 CEILING MARKER INSTALLATION

A. Locate ceiling markerto locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

3.7 EQUIPMENT IDENTIFICATION

A. Install nameplates and engraved plastic laminate signs for identification of each major item of mechanical equipment, each operational device, and on all other devices required by the Engineer. Provide additional signs and lettering as follows:

1. To distinguish between multiple units in close proximity.
2. To inform operator of operational requirements.
3. To indicate safety and emergency precautions.
4. To warn of hazards and improper operations.

B. Adjust lettering size based on viewing distance from normal location of identification:
1. Up to 6 feet: Minimum 1/2 inch.
2. Greater than 6 feet: Proportionally increase letter size based on recommendations above.
3. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.
4. Stencils may be used in lieu of nameplates when lettering greater than 1 inch is needed for proper identification because of distance from normal location of required identification.

C. Where equipment to be identified is concealed above acoustical ceilings or similar removeable concealment, equipment tags may be installed in the concealed space to reduce the amount of text in exposed sign.

D. Terminology:

1. Air handling units: AHU-1, AHU-2, etc.
2. Boilers: B-1, B-2, etc.
3. Duct coils: DC-1, etc.
4. Condensing Units: CU-1, CU-2, etc.
5. Computer room unit: CR-1, CR-2
6. Exhaust fans: EF-1, EF-2, etc.
7. Finned tube: FT-1, FT-2, etc.
8. Fan terminal units: FTU-1, FTU-2, etc.
9. Floor terminal heating units: MFT-1, MFT-2, etc.
10. Hot water radiators: RAD-1, RAD-2, etc.
11. Liquid chilling units: CH-1, CH-2, etc.
12. Make-up air units: MAU-1, MAU-2, etc.
13. Outside air units: OAU-1, OAU-2, etc.
14. Unit heaters: UH-1, UH-2, etc.
15. Pumps: P-1, P-2, etc.
16. Expansion tanks: ET-1, ET-2, etc.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General testing, adjustment, and balancing requirements.

B. Pre-testing, adjustment, and balancing of existing air systems.

C.

D. Testing, adjustment, and balancing of air systems.

E. Testing, adjustment, and balancing of domestic water systems.

F. This section excludes:
   1. Specifications for materials for patching mechanical systems;
   2. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.
   3. Requirements and procedures for piping and ductwork systems leakage tests.

1.2 DEFINITIONS

A. TAB: Testing, adjusting, and balancing.

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Data sheets arranged for collecting test data in logical order for submission and review. Data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. Examples include inlets and outlets on water terminals, inlets and outlets from air terminal units, and inlets and outlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: Duct or pipe containing the major or entire fluid flow of the system.

I. Submain: Duct or pipe containing part of the system capacity and serving two or more branch mains.

J. Branch main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.3 SUBMITTALS

A. Qualifications:

1. Submit qualifications of TAB agency.
2. Submit qualifications of TAB supervisor.

B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.

C. Sample Forms: Submit sample forms if they are other than the standard forms available from the certification association followed for the project.

D. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

E. Preconstruction Test Report:

1. Submit preconstruction test report of existing systems as indicated on the drawings. Submit report prior to start of construction on the affected systems for review and comment by the engineer. Reference Part 3 for test procedures.
2. Report format shall follow Draft Report procedures specified above.
3. Report shall include all information requested by the procedures for each system covered by the scope of work. Information omitted or missed during the initial or subsequent pretests shall be documented via additional site visits at no additional cost to the owner.

F. Progress Reports.

G. Certified TAB Reports:

1. General:

a. Submit within two weeks after completion of testing, adjusting, and balancing.
b. Revise TAB plan to reflect actual procedures and submit as part of final report.
c. Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

2. Draft Report: Submit draft copies of report for review prior to final acceptance of Project. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.
3. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 2 complete sets of final reports. The final report shall be certified proof of the following:

a. The systems have been tested, adjusted, and balanced in accordance with the referenced standards.

b. The report reflects an accurate representation of how the systems have been installed.
c. The report reflects a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures.
d. The report is an accurate record of all final quantities measured to establish normal operating values of the systems.

4. Report Format: Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, and cover identification at front and side. Include set of reduced size drawings indicating air outlets, equipment, and thermostat locations identified to correspond with report forms. Divide the report into the following divisions:

a. General Information and Summary

1) Include project name, location, altitude, and date.
2) Identify TAB agency, contractor, owner, architect, and engineer.
3) Include addresses, contact names, and telephone numbers.
4) Include certification sheet containing the seal, name, address, telephone number, and signature of the certified TAB Supervisor.
5) Include actual instrument list, with manufacturer name, serial number, and date of calibration.

b. Air Systems
c. Temperature Control Systems

5. Report Forms: Standard forms prepared by the TAB certification standard being followed for each respective item and system to be tested, adjusted, and balanced. If not specified, follow ASHRAE 111.
6. Units of Measure: Report data in I-P (inch-pound) units only.

H. Project Record Documents: Provide drawings that record actual locations of flow measuring stations and balancing devices.

1.4 QUALITY ASSURANCE

A. Comply with ASHRAE Standard 111, Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.

B. Comply with ASHRAE Handbook, HVAC Applications Volume, Chapter "Testing, Adjusting, and Balancing", most current edition.

C. TAB Agency Qualifications:

1. Act as the single source of responsibility for TAB of the HVAC systems.
2. Staff the project at all times by qualified personnel.
3. Have a minimum of 5 years documented experience on projects with TAB requirements similar to those required for the project.
4. Certified by one of the following Certification Associations:

a. AABC (NSTSB): Associated Air Balance Council, National Standards for Total System Balance.
b. NEBB: National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
c. TABB: Testing, Adjusting, and Balancing Bureau, SMACNA TAB Procedural Guide.

D. TAB Supervisor and Technician Qualifications:

1. Certified by the same organization as TAB agency.
2. TAB Supervisor shall be a professional engineer licensed in the state in which the project is located.

E. Pre-Qualified TAB Agencies:

1. AccuTech
2. Doyle Field Services.
3. Precisionaire of the Midwest.
4. Pro Balance.

PART 2 - PRODUCTS AND MATERIALS – NOT USED

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Begin work after systems to be tested, adjusted, or balanced are fully operational, duct systems are sealed, piping systems have been tested for leaks, and equipment is operational. Complete work prior to Substantial Completion of the project.

B. Test, adjust, and balance the air systems before and refrigerant systems.

C. Test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design condition. Take final temperature readings during seasonal operation.

D. Coordinate with Division 22 drawings for testing, adjusting, and balancing scope of work.

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

F. Submit progress reports at least once a week to the General Contractor to communicate status of work so that the TAB work is completed in a timely manner.

G. Notice of Tests: Provide seven days advance notice for each test. Include scheduled test dates and times.

H. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

I. All required instrumentation shall be calibrated to tolerances specified in the referenced standards within a period of six months prior to starting the project.

3.2 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Systems are started and operating in a safe and normal condition.
2. Temperature control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Motors and bearings are lubricated.
5. Final filters are clean and in place. If required, install temporary media in addition to final filters.
6. Duct systems are clean of debris.
7. Fans are rotating correctly and belts have tension.
8. Fire, smoke, fire/smoke, and volume dampers are in place and open.
9. Air coil fins are cleaned and combed.
10. Volume dampers are installed at locations needed for balancing the air systems.
11. Access doors are closed and duct end caps are in place.
12. Air outlets are installed and connected.
13. Visually inspect duct systems to ensure they are sealed and leakage is minimized.

B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a coordination meeting with all installers whose work will be tested, adjusted, or balanced.

B. Furnish all instruments required for testing, adjusting, and balancing operations.

1. Verify all instruments have been calibrated.
2. Furnish instruments as recommended by the manufacturer for the TAB application.
3. Furnish instruments that are best suited to the function being measured.
4. Furnish instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.

C. Furnish additional balancing devices as required for TAB to the appropriate contractor for installation.

D. Obtain copies of approved shop drawings of air handling equipment, terminal outlets, and temperature control diagrams.

E. Obtain manufacturer's fan and terminal device outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.

F. Determine best locations in main and branch ductwork for most accurate duct traverses.

G. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.

3.4 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Balance main ducts and equipment to within plus or minus 5 percent of design airflow.

B. Air Outlets and Inlets: Balance branch ducts and terminal devices to within plus or minus 10 percent of design airflow.

3.5 RECORDING AND ADJUSTING

A. Record data regarding design conditions from contract documents and installed conditions from shop drawings including equipment identification number, model number, location, area served, manufacturer, model number, serial number, motor nameplate horsepower and rpm, fan rpm, capacity and electrical voltage, amps and phases.

B. For all systems measure and record the ambient conditions at the time of testing and balancing. Include the following:

1. Dry bulb temperature.
2. Relative humidity.
3. Cloud cover.
4. Wind speed.
5. Time.

C. Field Logs: Maintain written logs including:

1. Running log of events and issues.
2. Discrepancies, deficient or uncompleted work by others.
3. Contract interpretation requests.
4. Lists of completed tests.

D. Ensure recorded data represents actual measured or observed conditions.

E. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

F. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

G. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

H. Cut insulation around ductwork and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

I. Patch and seal insulation, vapor barrier, ductwork, and housings, using materials identical to those removed.

J. Seal ducts and piping and test and repair leaks.

K. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

L. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

M. Check and adjust systems approximately six months after final acceptance and submit report.

N. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive values are obtained.

O. Take all readings at eye level of the indicated value to prevent parallax.

P. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

Q. Take measurements in the system where best suited for the task.

R. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.6 PRE-TESTING, ADJUSTMENT, AND BALANCING OF EXISTING AIR SYSTEMS

A. Perform preconstruction inspection and testing of existing systems as noted on the plans. Submit test report to engineer for approval. Construction on or demolition of the pre-tested systems shall not proceed until the engineer has reviewed and approved the preconstruction test report.

B. TAB Contractor:

1. Measure and record the operating speed, airflow, and total and external static pressure of each fan system. Provide individual pressure drop readings across all coils, filter banks, dampers and other internal fan system components
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the condition of filters.
4. Check the condition of coils.
5. Check the operation of the drain pan and condensate-drain trap.
6. Check bearings and other lubricated parts for proper lubrication.
7. For variable air volume systems: Open automatic air dampers to full design position to simulate a design day. Measure and record the operating speed and airflow of each fan system for full load conditions.
8. Report on the results of the measurements taken and any deficiencies.

C. Mechanical Contractor:

1. Check the refrigerant charge.
2. Report on the operating condition of the equipment and any deficiencies.

3.7 AIR SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Check filters for cleanliness.

B. Check dampers (both volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.

C. Verify volume dampers are installed at locations needed for balancing the air systems.

D. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.

E. Determine best locations in main and branch ductwork for most accurate duct traverses.

F. Place outlet dampers in the full open position.

G. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.

H. Lubricate all motors and bearings.

I. Check fan belt tension.

J. Check fan rotation.

K. Energize fan motors and adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude. Replace fan and motor pulleys as required to achieve design conditions.

L. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

M. Measure air quantities at air inlets and outlets.

N. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

O. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Affect volume control by duct internal devices such as dampers and splitters.

P. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

Q. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

R. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

S. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

T. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

U. Where modulating dampers are provided, take measurements and balance at design conditions. Balance variable volume systems at design air flow rate and at minimum air flow rate.

V. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship to maintain building pressure setpoint.

W. Procedure for establishing minimum and absolute minimum outdoor air damper position on air handling units:

1. Open the minimum outdoor air damper and return air damper fully. Close the economizer air damper.
2. Operate supply fan at design speed and measure the outdoor airflow.
3. If the outdoor airflow is above the scheduled minimum ventilation airflow, adjust the damper linkage on the minimum outdoor air damper so that outdoor airflow equals the scheduled minimum ventilation airflow with damper fully stroked.
4. If outdoor airflow is below the scheduled minimum ventilation airflow, adjust the damper linkage on the return air damper so that outdoor airflow equals the schedule minimum ventilation airflow with the damper fully stroked.
5. Convey the measured setpoint and/or damper position to the BAS installer and note on air balance report.
6. Repeat this procedure to determine damper position for absolute minimum ventilation.

3.8 DOMESTIC WATER SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Before balancing the system perform these steps:

1. Open valves to full open position.
2. Examine plumbing system and equipment installations to verify that indicated balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices and balancing valves and fittings are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
3. Remove and clean all strainers.
4. Check pump rotation.
5. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
6. Lubricate all motors and bearings.

END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.

B. External Ductwork Insulation.

1.2 RELATED REQUIREMENTS

A. Division 23 Section "Hangers & Supports for HVAC Piping & Equipment," for insulation shields, pipe saddles, and high-density insulation inserts.

B. Division 23 Section "Metal Ducts" for duct liner insulation.

1.3 DEFINITIONS

A. Cold Pipe: Piping that carries fluid with a minimum operating temperature less than 60 degrees F.

B. Hot Pipe: Piping that carries fluid with a minimum operating temperature greater than 105 degrees F.

C. Cold Duct: Ductwork that carries airflow with a minimum operating temperature less than 65 degrees F temperature.

D. Hot Duct: Ductwork that carries airflow with a minimum operating temperature greater than 75 degrees F temperature.

E. Neutral Ductwork: Ductwork that carries airflow with temperatures between the defined cold and hot temperatures.

F. Exposed: Insulation that is visible from the occupied space or where lay-in / hard ceiling fully enclosing a plenum is not present.

G. Exposed to Weather: Insulation that is exposed to potential damage caused by weather, including sunlight, moisture, wind, and solar radiation.

H. Exterior: Locations outside of or within the building envelope (walls, roof, floors, etc) as defined by the architectural drawings and specifications.

I. Unconditioned Spaces: An enclosed space within a building that is not provided with mechanical heating or cooling.

1.4 SUBMITTALS

A. Product Data: Submit technical product data, thermal characteristics, and materials for each type of mechanical insulation.

B. Insulation Schedule: Include product name, conductivity k-value, thickness, and furnished accessories for each service.

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

D. Manufacturer's Instructions: Include installation instructions for storage, handling, protection, examination, preparation, and installation of the product.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualification: Company specializing in manufacturing the products specified in this section with not less than three years of documented experience.

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. Flame/Smoke Ratings: 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 UL 723 or ASTM E84 (NFPA 255) method.

1. Exception: Exterior mechanical insulation may have flame spread index of 75 and smoke developed index of 150.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage; store in original wrapping.

1.7 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 - PRODUCTS

2.1 PIPING INSULATION MATERIALS

A. Flexible Elastomeric:

1. Manufacturers:

   a. Aeroflex USA, Inc.
   b. Armacell LLC.
   c. K-Flex USA.

2. Insulation: ASTM C534, Grade I, flexible elastomeric cellular rubber insulation, pre-formed for the application.

   a. K-value: ASTM C518 or C177, maximum 0.28 at 75 degrees F.
   b. Minimum Service Temperature: Minus 297 degrees F
   c. Maximum Service Temperature: 220 degrees F for Grade I, 300 degrees F for Grade II.

B. Field-Applied Jacket:

1. Rigid Aluminum Shell: One-piece, pre-formed cover conforming to ASTM C1729 with weather-proof construction. Shell shall have the following minimum thickness based on the outer insulation diameter:

Outer Insulation Diameter (in)	Minimum Aluminum Jacket Thickness, (in) Non-Rigid Insulation	Rigid Insulation	Finish
≤ 8	0.016	0.016	Stucco

Note 1: Use corrugated finish for non-rigid insulation. Use stucco finish for rigid insulation.

   a. Banding:

      1) For piping less than or equal to 8 inches, provide 0.020 inch thick, 3/4 inch wide aluminum bands.
      2) For piping larger than 8 inches, provide 0.020 inch thick, 3/4 inch wide stainless steel bands.

2. Multilayer Laminate Vapor Barrier Cladding: UV-resistant multi-ply outer layer and cold weather acrylic adhesive. Provide VentureClad Plus 1579 CW, or approved equal.

   a. Water Vapor Transmission: 0.0 perms per ASTM E96.
   b. Puncture Resistance: Minimum 65 pounds per ASTM D1000.

3. Rubberized Asphalt Vapor Barrier Cladding: UV-resistant aluminum outer layer, multi-ply cross-laminated polyethylene film, and rubberized asphalt formulated for use on faced insulated duct and piping applications. Provide Polyguard Products, Inc. Alumaguard 60 mils thick cladding, Alumaguard Low Temp (LT) 35 mils thick cladding, or approved equal.

   a. Water Vapor Transmission: 0.0 perms per ASTM E96.
   b. Puncture Resistance: Minimum 15 pounds per ASTM D1000.

C. Pipe Insulation Accessories: Provide staples, bands, wires, cement, and other appurtenances as recommended by insulation manufacturer for applications indicated.

D. Adhesives, Sealers, Mastics, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

1. Lagging Adhesive: Comply with MIL-A-3316C, Class 1, Grade A. Provide Foster 30-36, Childers CP-50AHV2, or equal.
2. Weather Barrier Breather Mastic: Permeance shall be 1.0 perms or less at 62 mils dry per ASTM E96, Procedure B. Provide Foster 46-50, Childers CP-10/11 or equal.

3. Solvent-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 35 mils dry per ASTM F 1249.
4. Water-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance in accordance with ASTM C755 for insulation application. Provide Foster 30-80, Childers CP-38, or equal.

Table: Recommended Maximum Permeance of Water Vapor Retarders (Note 1)

Insulation Application	Insulation Permeability, Less than 4.0 perm-in. (Note 2)	Insulation Permeability, 4.0 or greater perm-in. (Note 2)
	Vapor Retarder perms	Vapor Retarder perms
Pipe and vessels (33 F to ambient)	0.05	0.05
Pipe and vessels (-40 F to 32 F)	0.02	0.02
Ducts (40 F to ambient)	1.0	0.03

Notes:

1. Water vapor permeance of the vapor retarder in perms when tested in accordance with Test Methods E96.
5. Water vapor permeability of the insulation material when tested in accordance with Test Methods E96.

E. Insulation Diameters: Comply with ASTM C585 for inner and outer diameters of rigid thermal insulation.

F. Pipe, Valve and Fitting Covers: Comply with ASTM C450 for fabrication of fitting covers for pipe, valves and fittings.

G. High Density Insulation Billets:
1. Flexible elastomeric: ASTM C534, Type 1.

2.2 EXTERNAL DUCTWORK INSULATION MATERIALS

A. Flexible Mineral Fiber (rock, slag, or glass):

1. Manufacturers:

a. CertainTeed Corp.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.

2. Insulation: ASTM C553, Type I or II, flexible mineral fiber blanket.

a. K-value: ASTM C518 or C177, maximum 0.31 at 75 degrees F.
b. Minimum Service Temperature: Minus 20 degrees F
c. Maximum Service Temperature: 450 degrees.
d. Density:
1) 1.5 pounds per cubic foot.

3. Factory Applied Vapor Barrier Jacket: ASTM C1136, Type II.

a. Foil Scrim Kraft (FSK): Kraft paper with glass fiber yarn and bonded to aluminized film, water vapor permeance of 0.02 perms and 2 inch stapling tab.

b. Polypropylene Scrim Kraft (PSK): Kraft paper with glass fiber yarn and bonded to metalized polypropylene, water vapor permeance of 0.02 perms and 2 inch stapling tab.
c. Color: [White][Black].

B. Flexible Elastomeric:

1. Manufacturers:

a. Aeroflex USA, Inc.
b. Armacell LLC.
c. K-Flex USA.

2. Insulation: ASTM C534, Grade 1, flexible elastomeric cellular rubber insulation, sheet form.

a. K-value: ASTM C518 or C177, maximum 0.28 at 75 degrees F.
b. Minimum Service Temperature: Minus 40 degrees F
c. Maximum Service Temperature: 180 degrees F.

3. Factory Applied Jacket:

a. Flexible Metal Cladding: Metallic factory-laminated cladding, 17.5 mils thick, designed to prevent damage to underlying insulation from sunlight, installation, and physical abuse, with water vapor permeance of 0.00 perms. Provide ArmaTuff or equal. Reference Duct Jacket Schedule in Part 3 of this specification for application of this jacket.

C. Field-Applied Jacket:

1. Aluminum: ASTM B209, 3003 alloy, H-14 temper, with 3-mil thick polyfilm moisture barrier to interior surface.

a. Thickness: 0.032 inch sheet.
b. Finish: Smooth or Stucco. Reference Part 3 for jacket applications.
c. Joining: Longitudinal slip joints and 2 inch laps.
d. Fittings: 0.032 inch thick die shaped fitting covers with factory attached protective liner.
e. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel.

2. Multilayer Laminate Vapor Barrier Cladding: UV-resistant multi-ply outer layer and cold weather acrylic adhesive. Provide VentureClad Plus 1579 CW, or approved equal.

a. Water Vapor Transmission: 0.0 perms per ASTM E96.
b. Puncture Resistance: Minimum 65 pounds per ASTM D1000.

3. Rubberized Asphalt Vapor Barrier Cladding: UV-resistant aluminum outer layer, multi-ply cross-laminated polyethylene film, and rubberized asphalt formulated for use on faced insulation. Provide Polyguard Products, Inc. Alumaguard 60 mils thick cladding, Alumaguard Low Temp (LT) 35 mils thick cladding, or approved equal.

D. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, pins with insulation retaining washers, anchors, corner angles and other appurtenances as recommended by insulation manufacturer for applications indicated.

E. Adhesives, Sealers, Mastics, and Protective Finishes: Provide cements, adhesives, coatings, sealers, mastics, protective finishes, and similar compounds as recommended by insulation manufacturer for applications indicated.

1. Mineral Fiber Lagging Adhesive: Comply with ASTM C916, Type 2 or MIL-A-3316C, Class 2, Grade A. Provide Foster 85-60, Childers CP-127, or equal water-based adhesive.
2. Vapor Barrier Tape: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber-based adhesive.
3. Water-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 47 mils dry per ASTM E96. Provide Fosters 30-80, Childers CP-38, Design Polymerics 3040, or equal.
4. Solvent-Based Vapor Barrier Mastic: Comply with MIL-PRF-19565C, Type II, with water vapor permeance 0.05 perms or less at 35 mils dry per ASTM F 1249.
5. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test piping and ductwork for design pressure, liquid tightness, and continuity prior to applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 PROTECTION AND REPLACEMENT

A. Provide all required protection for insulation (installed and uninstalled) throughout the duration of construction to avoid exposure to plaster, dust, dirt, paint, moisture, deterioration, and physical damage.

B. Repair existing mechanical insulation that is damaged during this construction period. Use insulation of same type and thickness as existing insulation. Install new jacket lapping and sealed over existing.

C. Replace damaged insulation which cannot be repaired satisfactorily at no additional expense to the Owner, including insulation with vapor barrier damage and insulation that has been exposed to moisture during shipping, storage, or installation. Drying the insulation is not acceptable. Dry surfaces prior to installation of new insulation that replaces the damaged or wet insulation.

3.3 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

3.4 PIPING SYSTEM INSULATION INSTALLATION

A. Maintain continuous thermal and vapor-retarder integrity throughout entire installation and protect it from puncture and other damage.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Exposed Piping: Locate insulation and cover seams in least visible locations.

E. Cold Pipe Insulation:

1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
2. Provide vapor barrier jacket according to the Piping Jacket Schedule.
3. Provide high density insulation material under supports or pre-insulated supports. Protect insulation with shields to prevent puncture or other damage. Refer to Section "Hangers & Supports for HVAC Piping & Equipment" for pre-insulated supports and insulation shields. and for exception where high density insulation inserts are not required.
4. High density insulation material shall extend a minimum 2 inches past the pipe shield on each side.
5. Secure all-service jacket with self-sealing longitudinal laps.
6. Butt pipe insulation tightly at insulation joints. Apply wet coat of vapor barrier lap cement on joint and seal with 3 inch wide vapor barrier tape or band and coat all taped seams and staple penetrations with vapor barrier coating to prevent moisture ingress.

F. Hot Pipe Insulation:

1. Insulate entire system, including fittings, valves, unions flanges, strainers, flexible connections, pump bodies, and expansion joints.
2. Provide jackets without vapor barrier according to the Piping Jacket Schedule. Jackets with vapor barrier are allowed.
3. Provide high density insulation material or pre-insulated supports where supports are installed outside of the insulation. Protect insulation with shields to prevent puncture or other damage. Refer to Section "Hangers & Supports for HVAC Piping & Equipment" for pre-insulated supports and insulation shields and for exception where high density insulation inserts are not required.
4. High density insulation material shall extend a minimum 2 inches past the pipe shield on each side.
5. Secure all-service jacket with self-sealing longitudinal laps.
6. Butt pipe insulation tightly at insulation joints and wrap insulation around supports. Apply 3 inch wide vapor barrier tape or band over joint.

G. Insulation of Fittings, Valves, Strainers, Flanges, and Unions:

1. Insulate fittings, joints, and valves with molded insulation of like material, vapor barrier coating, and thickness as adjacent pipe. Provide pre-formed insulation pieces, segmented insulation, or sectional pipe insulation for the application. Provide the same insulation jacket as adjoining pipe.
2. Sectional pipe insulation: Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Hold sectional cuts in place with tie wire or bands. Wire and bands shall be compatible with insulation and jacket.
3. Segmented pipe insulation: Cover segmented insulated surfaces with a layer of finishing cement and finish with a coating or mastic. Reinforce the mastic with fabric-reinforcing mesh. Trowel the coating or mastic to a smooth and well-shaped contour.

4. Butt each insulation piece tightly against adjoining piece of insulation. Bond pieces together according to Cold Pipe or Hot Pipe installation instructions.
5. Insulate valves up to and including the bonnets, valve stuffing-box studs, bolts, and nuts with a removeable insulation cover. Sectional valve insulation covers shall divide the section along the vertical center line of the valve body.
6. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover.
7. Insulate flanges and unions with a removeable insulation cover. Sectional pipe insulation covers shall divide the section along the center line of pipe.
8. When removeable covers are made from sectional block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, around the insulated device with tie wire. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
9. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation. PVC fitting covers with end caps are also acceptable. Tape PVC covers to adjoining insulation facing using PVC tape.

H. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

I. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated. Maintain vapor barrier through the penetration.

J. Exterior Piping and Piping Exposed to Weather:

1. General: Provide piping jacket around insulation as scheduled in the Piping Jacket Schedule. Jacket material shall be approved by the jacket manufacturer for use with the specific insulation material that it covers. Locate longitudinal seams of outer shell (aluminum, flexible elastomeric, or cladding as applicable) at bottom of pipe. Provide insulation shields so that the piping supports cannot puncture, cut or break the jacket.
2. Rigid aluminum shell: Space attachment bands 12 inches on center and directly centered over end joints.
3. Multilayer Laminate Vapor Barrier Cladding: Install cladding only when ambient temperature is above 50 degrees F. Provide low-temp products for installation in low ambient temperatures down to 10 degrees F.
4. Rubberized Asphalt Vapor Barrier Cladding: Install cladding for use in ambient temperatures as low as minus 10 degrees F.

3.5 PIPING SYSTEM INSULATION SCHEDULE

A. Reference Pipe Insulation Thickness Schedule at the end of this specification for thickness requirements based on insulation conductivity.

B. Do not apply insulation to piping that operates outside of the minimum and maximum service temperature range.

C. Omit insulation on the following:

1. Hot piping within radiation enclosures or unit cabinets.

2. Cold piping within unit cabinets provided piping is located over drain pan.
3. Heating piping between coil and shutoff valves provided piping is located within heated space and not more than three feet from coil.

D. Exterior Piping: Insulate all exterior HVAC piping with one of the following:
1. Flexible elastomeric, use high temperature formula for systems with operating temperatures above 220 F. (not acceptable for steam, steam condensate or hot water piping systems with temperatures above 300 F).

E. Sub-Zero Piping (Below 0 degrees F) (-18 degrees C)):

1. Service:

a. Ammonia refrigerant piping.
b. Low temperature refrigerant piping.

2. Acceptable Insulation:

a. Cellular glass.
b. Polyisocyanurate.
c. Flexible elastomeric.
d. Phenolic.
e. Polyolefin.

F. Sub-Freezing Piping (0 to 39 degrees F (-18 to 4 degrees C)):

1. Service:

a. Refrigerant liquid lines between the expansion valve and the evaporator coil.
b. Refrigerant suction lines between evaporator coil and compressor.

2. Acceptable Insulation:
a. Flexible elastomeric.

G. Warm Temperature Piping (105 degrees to 140 degrees F (40 to 94 degrees C)):

1. Service:
a. Refrigerant hot gas lines between the compressor and condensing unit.
b. Refrigerant liquid lines between the condensing unit and expansion valve.

2. Insulate each piping system specified above with one of the following types of insulation.
a. Flexible elastomeric.

3.6 PIPE INSULATION THICKNESS SCHEDULE

A. IECC – 2012 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

	Insulation Conductivity		Nominal Pipe or Tube Size (in.)				
Fluid Operating Temp. Range (°F) And Usage	Conductivity, Btu·in./(hr·ft²·°F)	Mean Rating Temp., °F.	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				

>350°F	0.32–0.34	250	4.5	5.0	5.0	5.0	5.0
251°F–350°F	0.29–0.32	200	3.0	4.0	4.5	4.5	4.5
201°F–250°F	0.27–0.30	150	2.5	2.5	2.5	3.0	3.0
141°F–200°F	0.25–0.29	125	1.5	1.5	2.0	2.0	2.0
105°F–140°F	0.21–0.28	100	1.0	1.0	1.5	1.5	1.5
40°F–60°F	0.21–0.27	75	0.5	0.5	1.0	1.0	1.0
<40°F	0.20–0.26	75	0.5	1.0	1.0	1.0	1.5

Notes:

a. For piping smaller than 1-1/2 inch and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch.
b. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: T = r{(1 + t/r)^(K/k) – 1} where

   1) T = minimum insulation thickness (in.),
   2) r = actual outside radius of pipe (in.),
   3) t = insulation thickness listed in this table for applicable fluid temperature and pipe size,
   4) K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in./hr·ft²·°F); and
   5) k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

c. Insulation thicknesses are based on energy efficiency considerations only. Add insulation where noted on the drawings.
d. For piping that shall be installed below grade, reference Division 23 section "Underground Hydronic and Steam Piping."
e. The table is based on steel pipe. Non-metallic pipes schedule 80 thickness or less shall use the table values. For other non-metallic pipes having thermal resistance greater than that of steel pipe, reduced thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown on the table.

3.7 PIPING JACKET SCHEDULE

A. Exposed piping within mechanical rooms (above 10 feet):
   1. Rigid aluminum shell.

B. Exposed piping:

   1. All-service jacket.
   2. Semi-rigid PVC.

C. Piping within return air plenums:

   1. All-service jacket.

D. Exterior piping and piping exposed to weather:
   1. Rigid aluminum shell.

2. Multilayer laminate vapor barrier cladding.
3. Rubberized asphalt vapor barrier cladding.

3.8 DUCTWORK INSULATION SYSTEM INSTALLATION

A. Maintain continuous thermal and vapor-barrier integrity throughout entire installation and protect it from puncture and other damage.

B. Install insulation on duct systems subsequent to painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces.

D. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Install insulation without sag on underside of duct. Where rectangular ducts are 24 inches in width or greater, secure external insulation to the bottom of the duct with mechanical fasteners, spaced on 18 inches on center (maximum). Fasteners shall include 2-inch square self-sticking galvanized carbon-steel base plates with minimum 0.106-inch diameter zinc-coated, low carbon steel, fully annealed shank spindle, length to suit depth of insulation. Secure insulation to spindles with self-locking washers incorporating a spring steel insert to ensure permanent cap retention. Lift duct off trapeze hangers and insert spacers to avoid insulation compression.

F. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

G. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

H. Lined Ductwork: At interface of lined and wrapped ductwork, overlap lined ductwork by 2 feet (minimum) with wrapped insulation.

I. Cold Ducts:

1. Insulate entire system, including fittings, joints, flanges, expansion joints, and air duct accessories.
2. Provide vapor barrier jacket according to the Ductwork Jacket Schedule.
3. Seal joints with vapor barrier mastic.
4. Continue insulation, including vapor barrier, through walls, sleeves, hangers, and other duct penetrations.
5. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
6. Where cold ducts are installed in mechanical rooms or non-conditioned spaces (excludes return air plenums), prevent condensation from forming on the duct supports by providing one or more of the following:

    a. Install thermal break such as rigid board insulation between the support and duct.
    b. Wrap support that is in contact with the duct with external duct wrap insulation to prevent condensation. Wrap shall extend a minimum of 12 inches from point of contact of the support with the duct. Tape joints to provide a thermal and vapor barrier. Coat all taped joints, punctures and seams with 4 inch wide coating of vapor barrier mastic.
    c. If a support device similar to Unistrut is used, foam fill or stuff tube.

J. Hot and Neutral Ducts:

1. Insulate entire system, including fittings, joints, flanges, expansion joints, and air duct accessories.
2. Provide jackets with or without vapor barrier according to the Ductwork Jacket Schedule.
3. Secure joints with staples, tape, or wires.
4. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

K. Exterior Ductwork and Ductwork Exposed to Weather:

1. Slope ductwork to ensure that water cannot pond anywhere on the duct. Do not vary the insulation thickness to achieve drainage.
2. Jackets shall be approved by the jacket manufacturer for use with the specific insulation material it covers.
3. Locate longitudinal seams of jacket at bottom of duct. Install jacket in strict conformance with cladding manufacturer's instructions.
4. Seal joints with vapor barrier mastic and reinforcing mesh as recommended by manufacturer or protective jacket as specified.
5. Install aluminum jacket with three metal jacket bands per section.
6. Multilayer Laminate Vapor Barrier Cladding: Install cladding only when ambient temperature is above 50 degrees F. Provide low-temp products for installation in low ambient temperatures down to 10 degrees F.
7. Rubberized Asphalt Vapor Barrier Cladding: Install cladding for use in ambient temperatures as low as minus 10 degrees F.
8. Cover seams in flexible metal cladding with ArmaTuff seal tape or equal.

3.9 DUCTWORK SYSTEM INSULATION SCHEDULE

A. Omit insulation on the following:
1. Lined ductwork.
2. Ductwork with sound absorbing linings.

B. Prohibited insulation:

1. Polyisocyanurate installed within a return air plenum.

C. Outdoor Air:

1. Service:

a. Interior untreated outdoor air intake ducts.
b. Pre-conditioned outdoor air ducts.

2. Acceptable Insulation:

a. Flexible mineral fiber.
b. Rigid mineral fiber.
c. Flexible elastomeric.

D. Supply Air:

1. Service:

a. Supply ducts from air handling equipment.

2. Insulate neck and bells of supply diffusers.In locker rooms with shower areas and shower areas. Acceptable Insulation:

    a. Flexible mineral fiber.
    b. Rigid mineral fiber.
    c. Flexible elastomeric.

E. Return Air:

1. Service:

    a. Interior ductwork within 10 feet of exterior roof or wall penetrations.
    b. Interior ductwork routed through or from unconditioned spaces and plenums.

2. Acceptable Insulation:

    a. Flexible mineral fiber.

F. Exhaust Air.

1. Service:

    a. Interior ductwork within 10 feet of exterior roof or wall penetrations.
    b. Interior ductwork downstream of heat recovery device (wheel, plate, heat pipe, etc.) to exterior discharge outlet.
    c. Exterior ductwork upstream of heat recovery device (wheel, plate, heat pipe, etc.).
    d. Dishwasher exhaust ducts within 10 feet of discharge to the outdoors.

2. Acceptable Insulation:

    a. Flexible mineral fiber.

G. Relief Air.

1. Service:

    a. Interior ductwork within 10 feet of exterior roof or wall penetrations.
    b. Downstream of heat recovery device (wheel, plate, heat pipe, etc.) to exterior discharge outlet.

2. Acceptable Insulation:

    a. Flexible mineral fiber.

H. HVAC plenums and unit housings not pre-insulated at factory or lined.

1. Acceptable Insulation:

    a. Flexible mineral fiber.

I. Exterior Ductwork:

1. Service:

    a. Supply ductwork.

b. Return ductwork.
c. Exhaust ductwork.
d. Pre-conditioned outside air downstream of conditioning unit.

2. Acceptable Insulation:
a. Flexible elastomeric.

3.10 DUCT SYSTEM INSULATION THICKNESS SCHEDULE

A. Flexible Mineral Fiber:

1. Interior Ductwork:
a. 1.5 pounds per cubic foot density:
1) 2 inch thick, minimum R-6.0.

2. Meet R-value installed at maximum 25% compression, application limited to concealed locations.

B. Flexible Elastomeric:

1. Interior Ductwork:
a. 1-1/2 inch thick, minimum R-6.0.

2. Exterior Ductwork or Ductwork Exposed to Weather:

a. 2 inch thick, minimum R-8.0.
b. Two layers of 1-1/2 inch thick, minimum R-12.0.

3. Ductwork in an Unconditioned Space:

a. 1-1/2 inch thick, minimum R-6.0.

3.11 DUCTWORK JACKET SCHEDULE

A. Omit jacket on internally lined ductwork.

B. Exposed ductwork within mechanical rooms (above 10 feet):

1. Foil Scrim Kraft (FSK).
2. All-Service Jacket (ASJ).
3. Flexible Metal Cladding (flexible elastomeric only).

C. Exposed ductwork:

1. Foil Scrim Kraft (FSK).
2. All-Service Jacket (ASJ).
3. Flexible Metal Cladding (flexible elastomeric only).
4. Aluminum with smooth finish.

D. Ductwork within return air plenums:

1. Foil Scrim Kraft (FSK).
2. All-Service Jacket (ASJ).
3. Flexible Metal Cladding (flexible elastomeric only).

E. Ductwork in an unconditioned space:

1. Foil Scrim Kraft (FSK).
2. All-Service Jacket (ASJ).
3. Flexible Metal Cladding (flexible elastomeric only).

F. Exterior ductwork and ductwork exposed to weather:

1. Flexible Metal Cladding (flexible elastomeric only).
2. Aluminum with stucco finish.
3. Multilayer Laminate Vapor Barrier Cladding.
4. Rubberized Asphalt Vapor Barrier Cladding.
5.

END OF SECTION

SECTION 230800 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Commissioning process requirements for HVAC systems, assemblies, and equipment.

1.2 SUMMARY

B. Retain the services of a third-party registered design professional or approved agency that is regularly engaged in conducting commissioning to develop a commissioning plan, supporting documentation, and reports.

A. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned shall be responsible for the commissioning activities relating to that system or equipment item.

B. The Commissioning Authority (CxA) shall direct and coordinate all commissioning activities and provide Prefunctional Checklists and Functional Test Procedures for Contractor's use.

C. The entire HVAC system and its appurtenances shall be commissioned, including controls, ductwork, piping, noise and vibration control devices, specialty systems (e.g., smoke control systems), and other systems identified elsewhere in the Contract Documents.

D. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

1.3 RELATED REQUIREMENTS

A. Division 01 Commissioning requirements that apply to all types of work.

1.4 REFERENCE STANDARDS

A. ASHRAE Guideline 0 – The Commissioning Process, most current edition.

B. - The HVAC Commissioning Process; most current edition.

1.5 DEFINITIONS

C. Refer to Division 01 "General Commissioning Requirements" for additional abbreviations and definitions.

A. BAS: Building Automation System.

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

C. Commissioning Authority (CxA): An entity identified by the Owner who coordinates the commissioning team to implement the Commissioning Process.

D. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.

E. Commissioning Process: A quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the OPR. Commissioning is intended to achieve the following objectives:

1. Verify that applicable systems and equipment are designed and installed according to the manufacturer's recommendations and to industry accepted minimum standards.
2. Verify that applicable systems and equipment receive adequate operational checkout by installing contractors.
3. Verify and document proper performance of equipment and systems.
4. Verify that O&M documentation provided to the Owner is complete.
5. Verify that the Owner's operating personnel are adequately trained.

F. Commissioning Report: A report that includes the following:

1. Results of final functional performance tests. Organize equipment and components specified by other Divisions in separate sections for independent review.
2. List of functional performance testing procedures used during commissioning, including measurable criteria for test acceptance.
3. Itemization of resolved deficiencies found during preliminary commissioning.
4. List of deferred tests that cannot be performed at the time of final commissioning report preparation because of climatic conditions.

G. Functional Performance Test (FPT): A test that verifies the equipment or item being tested performs in the manner intended.

H. Operations and Maintenance Manual (O&M): A system-focused composite document that includes the operation manual, maintenance manual, and additional information of use to the Owner during the occupancy and operation of the building.

I. Pre-Functional Checklist (PFC): A checklist that verifies all components and accessories related to a system that will be subjected to an FPT are present and functional.

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

K. TAB: Testing, Adjusting, and Balancing.

1.6 SUBMITTALS

A. Updated Submittals: Keep the Commissioning Authority informed of all changes to the HVAC system documentation made during installation, and startup; revise and resubmit when substantial changes are made.

D. Submit a commissioning plan that includes the following:

1. General project information and commissioning goals.
2. Commissioning team information.
3. Narrative description of commissioning process activities, schedules, responsibilities, and personnel required during commissioning.
4. List of equipment and systems to be tested with description of tests to be performed. Include an explanation of the original design intent.
5. List of functions to be tested, including calibration and economizer controls.
6. List of conditions under which the tests shall be performed.
7. List of measurable criteria for performance.

B. Draft Prefunctional Checklists and Functional Test Procedures for Control System: Detailed written plan indicating the procedures to be followed to test, checkout and adjust the control system prior to full system Functional Testing; include at least the following for each type of equipment controlled:

1. System name.
2. List of devices.
3. Step-by-step procedures for testing each controller after installation, including:

    a. Process of verifying proper hardware and wiring installation.
    b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
    c. Process of performing operational checks of each controlled component.
    d. Plan and process for calibrating valve and damper actuators and all sensors.
    e. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

4. Copy of proposed log and field checkout sheets to be used to document the process; include space for initial and final read values during calibration of each point and space to specifically indicate when a sensor or controller has "passed" and is operating within the contract parameters.
5. Description of the instrumentation being used for testing.
6. Indicate the tests required on each system that should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Authority and TAB contractor for this determination.

C. Submit startup reports pre-functional tests, and trend logs for review by the Commissioning Authority.

E. Submit a copy of the preliminary commissioning report. Preliminary commissioning report shall include the following:

1. Results of preliminary functional performance tests. Organize equipment and components specified by other Divisions in separate sections for independent review.
2. List of functional performance testing procedures used during commissioning, including measurable criteria for test acceptance.
3. Completed Commissioning Compliance Checklist.
4. Itemization of deficiencies found during testing that have not been corrected at the time of preliminary commissioning report preparation.
5. List of deferred tests that cannot be performed at the time of preliminary commissioning report preparation because of climatic conditions.
6. List of climatic conditions required for the performance of the deferred tests.

F. Submit a final commissioning report that includes the following:

1. Results of final functional performance tests. Organize equipment and components specified by other Divisions in separate sections for independent review.
2. List of functional performance testing procedures used during commissioning, including measurable criteria for test acceptance.
3. Itemization of resolved deficiencies found during preliminary commissioning.
4. Submit report to the Engineer and Owner within 90 days of the date of receipt of the certificate of occupancy.

D. Project Record Documents:

1. Submit as-built drawings indicating changes that occurred during the construction phase.
2. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
3. Show actual locations of all sensors on project record drawings.

G. O&M Manual: The O&M manual shall expand upon the more traditional operating and maintenance documentation to include information gathered during the commissioning process. Include the following for each system:

1. Manufacturer information.
2. Equipment specifications and recommendations.
3. Programming procedures and data points.
4. Narratives.
5. Other means of illustrating to the Owner how the building, equipment, and systems are intended to be installed, maintained, and operated.
6. Label that includes required regular maintenance actions for equipment and systems.

    a. Include in the label the title or publication number for the O&M manual for the model and type of product.
7. As-built control schematics for each commissioned system.
8. As-built control sequences for each commissioned system, including final setpoints and list of all control points.
9. Final parameters of all peripheral equipment (e.g., final parameters resident in a VFD.)
10. Recommended operating procedures for each piece of primary equipment
11. Instructions for integrated building systems.
12. Recommended schedule of maintenance requirements and frequency, troubleshooting guidelines, and emergency procedures.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing. Unless otherwise noted such testing equipment will NOT become the property of Owner.

B. If not otherwise specified, provide test equipment certified and calibrated within the past year of use. Meet the following minimum accuracy requirements:

1. Temperature sensors and thermometers: Accuracy of plus/minus 0.5 degrees F and resolution of plus/minus 0.1 degrees F.
2. Pressure sensors: Accuracy of plus/minus 2.0 percent of value within the range of values being measured (not full range of sensor).

C. Equipment-Specific Tools: Where special testing equipment, tools, and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work. Such equipment, tools, and instruments shall become the property of Owner.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCESS OVERVIEW

A. The following narrative provides a brief overview of the typical commissioning tasks performed during the design, construction, acceptance, and post-occupancy phases and the general order in which they occur. Coordinate with the CxA to comply with the commissioning requirements of the project.

1. Owner furnishes documentation to support the OPR and BOD to the design team and CxA.
2. The design team prepares construction documents to meet the OPR and BOD.
3. The CxA develops the commissioning plan.
4. Plans are permitted and construction-related submittals for all commissioned equipment are provided to the CxA during the normal submittal process.
5. The CxA develops specific equipment PFCs and furnishes them to the contractor.
6. The CxA conducts a kick-off meeting early during construction and presents the commissioning process for the project.
7. The Contractor coordinates project construction and prepares the project for inspecting, acceptance testing, and PFCs.
8. The Contractor coordinates with the CxA to execute and document the PFCs. The CxA reports on the PFC process including an issues report.
9. PFCs are completed before start-up, testing and balancing, and functional testing.
10. The Contractor and responsible subcontractors shall document equipment start-up and initial checkout with assistance from manufacturer's technicians. The CxA may request copies of the manufacturer's or contractor's field start-up reports.
11. The CxA develops specific FPT plans for review by the Engineer, Contract Administrator and responsible subcontractors.
12. The Contractor coordinates TAB for the project.
13. Testing, adjusting and balancing of completed HVAC systems is completed and verified by the CxA.
14. The Contractor and responsible subcontractors complete the installation and checkout of all building control systems.
15. The CxA coordinates and executes the FPTs with the assistance of responsible subcontractors. The CxA reports on the testing process including all observed deficiencies.
16. The CxA develops a preliminary commissioning report.
17. Testing of other commissioned systems not requiring formal functional testing is completed.
18. The CxA reviews close-out documentation and schedules deferred testing.
19. The Contractor and CxA coordinate to compile the O&M manual.
20. The CxA verifies training as required by the Contract Documents is completed.
21. The CxA develops a final commissioning report.

3.2 PREPARATION

A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.

B. Furnish additional information requested by the Commissioning Authority.

C. Prepare a preliminary schedule for use by the Commissioning Authority. Develop the following schedules and update the schedule as appropriate during the course of construction:

1. Leakage testing of duct systems.
2. Pressure testing of piping systems.
3. Flushing and cleaning piping systems.
4. Equipment startup.
5. Testing, adjusting, and balancing systems.

D. Notify the Commissioning Authority when scheduled tests shall occur. When commissioning activities not yet performed or not yet scheduled will delay construction, notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.

E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.

1. Include cost of sheaves and belts that may be required for testing, adjusting, and balancing.

F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.

G. Provide temperature and pressure taps in accordance with the contract documents.

1. Provide a pressure/temperature plug at each water sensor that is an input point to the control system.

3.3 INSPECTING AND TESTING - GENERAL

A. Refer to the latest adopted edition of the applicable energy code for more information.

3.4 PREFUNCTIONAL CHECKOUT

A. Submit startup plans, startup reports, and PFCs for each item of equipment or other assembly to be commissioned.

B. PFCs shall demonstrate the commissioned equipment is properly installed and ready for startup and initial operation.

C. Perform the PFCs directed by the CxA for each item of equipment or other assembly to be commissioned.

D. Document items from the PFCs and startup that were not completed successfully.

E. Complete and submit all PFC forms and provide notice that the equipment is ready for testing, adjusting, and balancing.

F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.5 TESTING AND BALANCING COORDINATION

A. Coordinate commissioning schedule with TAB schedule.

B. Notify the CxA at least 7 days in advance of testing and balancing work. Provide access for the CxA to witness test TAB work.

C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.

D. All required Prefunctional Checklists, calibrations, startup, and component Functional Tests of the system shall be completed and approved by the CxA prior to starting TAB.

E. Coordinate with the BAS and TAB Contractor to make available technicians, instrumentation, and tools to assist the CxA in verification of data points associated with TAB of HVAC systems.

3.6 FUNCTIONAL PERFORMANCE TESTING

A. The CxA shall furnish FPT procedures to the subcontractors and equipment manufacturers for review for feasibility, safety, equipment, and warranty protection.

B. Perform the FPTs directed by the CxA for each item of equipment or other assembly to be commissioned, including equipment, controls, and economizers. FPTs shall demonstrate the following:

1. The operation, function, and maintenance serviceability for each commissioned equipment, component, and system is confirmed according to the approved plans and specifications.
2. The sequence of operations, including modes, backup modes (if applicable), alarms, and mode of operation upon a loss of power and restoration of power for each control device, equipment, component, and system. Reference section Control System Functional Testing below for more information.
3. Control devices, components, equipment, and systems are calibrated, adjusted, and operate in accordance with the approved plans and specifications.
4. Air economizers operated in accordance with manufacturer's specifications and specified sequence of operation.
5. Terminal units: For multiples of like equipment (VAV terminal units, unit heaters, etc.), commission a minimum of 50 percent of total number of units.

C. Coordinate with the responsible sub-contractors to provide trained technicians to perform commissioning tests and/or coordinate with equipment manufacturers to make available authorized technicians for the same purpose.

D. Test equipment under design conditions when possible. Impose simulated design conditions using an artificial load when it is not practical to test under design conditions. Provide additional equipment to impose simulated loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

1. The CxA may direct that set points be altered when simulating conditions is not practical.
2. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

E. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

F. If the Commissioning Plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

G. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.7 DEFERRED AND SEASONAL TESTING

A. If any PFC or FPT cannot be completed due to an unforeseen condition not within control of the Contract Administrator, defer execution of the PFC or FPT based on the recommendation of the CxA and approval of the Owner. Complete the affected testing as soon as practical.

B. During the warranty period, complete tests purposely delayed until weather conditions are closer to the system's design conditions. The CxA shall coordinate this activity. Any final adjustments to the O&M manuals and/or as-built drawings due to the testing shall be made by the CA.

3.8 OPERATION AND MAINTENANCE MANUALS

A. See Division 01 and Section "General Mechanical Requirements for HVAC" for additional requirements.

B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.

C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.

D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

3.9 DEMONSTRATION AND TRAINING

A. See Division 01 for additional requirements.

B. Complete all related commissioning requirements prior to final inspections.

C. Demonstrate operation and maintenance of HVAC system to Owner' personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.

D. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.

E. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned.

F. Provide the services of manufacturer representatives to assist instructors where necessary.

G. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

H. Document systems operations training in the commissioning report.

END OF SECTION 230800

SECTION 230913 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Control panels.

B. Control dampers.

C. Operators.

D. Flow measuring apparatus.

E. Input/Output sensors and transmitters.

F. Output control devices.

G. Power Supplies.

H. Thermostats.

I. Weather stations.

1.2 DEFINITIONS

A. BAS: Building Automation System.

B. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operations

C. DDC: Direct Digital Control.

D. EPDM: Ethylene Propylene Diene Monomer.

E. High voltage: 50 volts or higher.

F. Low voltage: Below 50 volts.

G. PTFE: Polytetrafluoroethylene.

H. TEFZEL: A modified ETFE (ethylene tetrafluoroethylene) fluoroplastic.

1.3 CONTRACTOR RESPONSIBILITIES

A. Reference Division 23 Section "Electrical Coordination for Mechanical Equipment" for contractor responsibilities.

B. BAS Contractor:

1. Installation of the BAS shall be by the BAS Contractor or their subcontractors.
2. Low voltage control wiring.
3. Coordinate high voltage control wiring to instrumentation and control devices with Division 26. Where high voltage power is required for instrumentation and control devices that is in addition to what is shown on the drawings, the BAS contractor shall cover the cost of providing this wiring.
4. All interlock wiring regardless of voltage (e.g., exhaust fan interlocked to supply fan).
5. Coordinate with Division 26 that motor starters are provided with auxiliary contacts as required for interlocks.
6. Coordinate power wiring to BAS controllers and instrumentation and control devices with Division 26.
7. Coordinate installation of back-box rough-in for wall-mounted control devices sensors, etc. with Division 26. Coordinate with mechanical contractor all locations, quantities, and sizes required for installation by Division 26.
8. Perform startup and demonstration services as specified in Section "Direct Digital Control for HVAC".

C. Sheet Metal Contractor:

1. Installation of automatic control dampers, smoke control dampers, and necessary blank off plates.
2. Access doors where and as required.

D. Mechanical Contractor:

1. Coordinate conduit and wall box rough-in, power wiring and magnetic starter requirements for controls and mechanical equipment with Division 26.

1.4 SUBMITTALS

A. Refer to Division 01 for submittal procedures.

B. Product Data: Provide description and engineering data for each control system component. Include dimensions, capacities, size, performance characteristics, electrical characteristics, and finishes of materials.

C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

D. Schedule for control actuators, including the following:

1. Tag.
2. Quantity.
3. Model number.
4. Equipment served.
5. Actuator Signal Type (Open/Close, Modulating 0-10 Vdc, 2-10 Vdc, 4-20 mA, etc.)
6. Torque required to close valve at pump shutoff head.
7. Selected actuator maximum torque output.

E. Manufacturer's Instructions: Provide for all manufactured components.

F. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

G. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.

H. Warranty: Submit manufacturer warranty and ensure forms have been filled out in Owner s name and registered with manufacturer.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

C. Control valves shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ANSI and MSS standards.

D. Measurement devices and sensors shall be calibrated using NIST traceable standards.

1.6 WARRANTY

A. Correct defective Work within a one year period after Substantial Completion.

B. Provide extended warranty for control devices and equipment as specified herein.

PART 2 - PRODUCTS

2.1 OWNER FURNISHED PRODUCTS

A. New Products: None/Not Applicable.

2.2 CONTROL PANELS

A. Construction:

1. Panel shall be UL 508A listed.
2. NEMA 250, general purpose utility enclosures with enameled finished face panel.
3. NEMA 4X utility enclosure for outdoor or wash-down applications.
4. Provide common keying for all panels.

2.3 CONTROL DAMPERS

A. Dampers shall be factory fabricated and sized as shown on drawings and as specified.

B. Individual damper sections shall not be larger than 48 inches x 60 inches. Provide a minimum of one damper actuator per section.

C. Performance: Test in accordance with AMCA 500-D.

1. Pressure Drop: Unless otherwise scheduled or indicated on the Drawings, size control dampers as follows:

a. Modulating Dampers: Provide dampers with linear flow characteristics. Size modulating dampers based on the smaller of the following.

1) Maximum velocity of 1,500 feet per minute.
2) Maximum Full-open air pressure drop of 0.1 inches W.C.

b. Two Position Dampers: Dampers shall be full duct size and selected to minimize pressure drop.

2. Leakage:

a. Motorized dampers for outdoor, exhaust and relief air and for shaft and stairway vents shall be Class I leakage and shall not exceed 4.0 CFM/square foot in full closed position at 1 inch W.G. pressure differential across damper.
b. Motorized dampers for other applications shall be Class II leakage.

D. Frames: Galvanized steel, extruded aluminum, or stainless steel, welded or riveted with corner reinforcement.

1. Use minimum 16 gauge for rectangular dampers.
2. Use minimum 20 gauge for round dampers.
3. For aluminum frames, use 1/8 inch thick material.
4. All damper frames shall have a flange for duct mounting.
5. Reference Part 3 Execution for application of the material type.

E. Blades: Galvanized steel, extruded aluminum, or stainless steel, maximum blade size 6 inches wide, 48 inches long, attached to minimum 1/2 inch shafts with set screws.

1. Use minimum 16 gauge for rectangular dampers.
2. Use minimum 16 gauge for round dampers.
3. For aluminum blades, use 1/8 inch thick material.
4. The blades shall be suitable for the air velocities to be encountered in the system.
5. Dampers longer than the maximum blade length shall be fabricated in sections.
6. Reference Part 3 Execution for application of the material type.

F. Blade Seals: Synthetic elastomeric inflatable or Neoprene, mechanically attached, field replaceable.

1. Installed along the top and bottom of the frame and on all mating surfaces.

G. Jamb Seals: Spring stainless steel.

1. Installed inside the frame sides.

H. Shaft Bearings: One of the following as recommended by manufacturer for the application:

1. Oil impregnated sintered bronze.

2. Graphite impregnated nylon sleeve with thrust washers at bearings.
3. Lubricant free, stainless steel, single row, ground, flanged, radial, antifriction type with extended inner race.
4. Molded synthetic bearings.

I. Linkage Bearings: One of the following as recommended by manufacturer for the application:

1. Oil impregnated sintered bronze
2. Graphite impregnated nylon.

J. Maximum Pressure Differential: 6 inches wg.

K. Temperature Limits: -40 to 200 degrees F.

L. Manufacturers:

1. Greenheck.
2. CESCO.
3. Pottorff.
4. Nailor.
5. Ruskin.

M. Reference the Damper Schedule in Part 3 for basis of design damper model and material for the application.

2.4 OPERATORS

A. General:

1. Voltage: Voltage selection shall be as required to achieve the required torque for the application.

   a. Reference Part 3 for Damper Operator Voltage Schedule.

2. Type: Motor operated, with or without gears. Motor type shall be continuous duty.
3. Construction:

   a. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
   b. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
   c. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

4. Field Adjustment:

   a. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
   b. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

5. Two-Position Actuators: Single direction, spring return or reversing type. End-switches shall be integral to the actuator to determine actuator status.

6. Modulating Actuators:

    a. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
    b. Control Input Signal:

        1) Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
        2) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-Vdc or 2- to 10-Vdc and 4- to 20-mA signals.
        3) Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.

    c. Programmable Multi-Function:

        1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
        2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

7. Integral Overload Protection:

    a. Provide against overload throughout the entire operating range in both directions.
    b. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

8. Attachment:

    a. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to device without the need for connecting linkages.
    b. Attach actuator to device drive shaft in a way that ensures maximum transfer of power and torque without slippage.

9. Temperature and Humidity:

    a. Temperature: Suitable for operating temperature range encountered by application.
    b. Humidity: Suitable for humidity range encountered by application, non-condensing.

10. Enclosure:

    a. Suitable for ambient conditions encountered by application.
    b. NEMA 4 for indoor wash-down or wet locations.
    c. NEMA 4X, Belimo ZS-300, or equivalent; for outdoor applications.
    d. Provide actuator enclosure with heater and control where required by application.

11. Stroke Time:

    a. Coordinate with stroke time indicated on the control drawings.
    b. Unless otherwise noted, select operating speed to be compatible with equipment and system operation.

B. Damper Operators:

1. Controls contractor shall size damper operator.
2. Sizing: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.

    a. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
    b. Provide one operator for maximum 20 sq ft damper section or maximum 7 in-lb/sq ft damper area.

3. Fail Positions:

    a. Spring return to normal position as indicated on freeze, fire, temperature, or loss of power protection. Normal positions are indicated on the control drawings.

        1) Return air damper, normally open.
        2) Outside air damper, normally closed.
        3) Exhaust/Relief air damper, normally closed.

    b. Operator shall fail in place for all other applications not listed under spring return.

C. Manufacturers:

1. Damper Operators:

    a. Belimo.

2.5 FLOW MEASURING APPARATUS

A. Airflow Measuring Stations

1. Sensor quantity and spacing shall comply with the Equal-Area or Log-Tchebycheff method as defined in the ASHRAE Handbook of Fundamentals.
2. Element Construction: Non-corrosive material such as stainless steel, aluminum, or cadmium-plated.
3. Stations and insertion elements utilizing thermal dispersion technology shall utilize hermetically sealed thermistors for each sensor and shall be factory calibrated to NIST traceable standards.
4. Stations and insertion elements using velocity pressure shall be tested and certified in accordance with AMCA 611.
5. Air Inlet Measuring Stations:

    a. Intended for location within an air inlet to equipment, such as a hood or louver.
    b. Elements:

        1) Element constructed of 316 stainless steel, factory mounted in a circular puck constructed of 14 gauge galvanized steel. Housing shall meet NEMA 1.
        2) Element shall not induce a measurable pressure drop, adversely affect fan performance or amplify the sound level within the fan system by its presence in the airstream.
        3) Element shall not be affected by the presence of moisture, dirt, or debris in the airstream and shall be unaffected by gusting wind.

4) Density corrected for ambient temperature variances and atmospheric pressure due to altitude.

c. Range: Minimum 100 to 2,400 fpm.
d. Accuracy: Plus/minus 5.0 percent of reading within the calibrated airflow range.
e. Manufacturers:

1) Air Monitor Corporation.
2) Approved equal.

6. Fan Inlet Air Flow Measuring Stations:

a. Located in the fan cone inlet with a minimum of two sensing elements.
b. Traverse Type Elements:

1) The elements shall not induce a measurable pressure drop, adversely affect fan performance or amplify the sound level within the fan system by its presence in the airstream.

c. Surface Mount Probes:

1) Thermal Dispersion Type: Two surface mounted thermal dispersion probes mounted on opposite ends of the fan cone shall monitor the airflow.
2) Velocity Pressure Type: The piezometer ring probes shall monitor the pressure difference between the largest and smallest diameters of the inlet cone venturi. High and low pressure sensors shall be connected to flow tubes extending to a termination plate mounted on the fan housing.

d. Range: Minimum 100 to 10,000 fpm.
e. Accuracy: Plus/minus 3.0 percent of the measured airflow range.
f. Manufacturers:

1) Air Monitor Corporation.
2) Ebtron.
3) Johnson Controls.
4) Ruskin.
5) Sensocon.

7. Signal Processor:

a. Microprocessor-based, field programmable, capable of local display of the measured airflow rate.
b. Factory calibrated to NIST traceable standards.
c. Accuracy: 0.1 percent of full scale, including linearity, hysteresis, dead band, and repeatability.
d. Output: 0 to 10 Vdc or 4-20 mA scaled output signal for remote monitoring.

2.6 INPUT/OUTPUT SENSORS AND TRANSMITTERS

A. General:

1. Performance Requirements:

a. Device must be compatible with project DDC controllers.
b. Elements used shall be general-purpose type.

c. Provide transmitters or transducers with sensors as required, with range suitable for the system encountered.

1) Transmitters and transducers shall have offset and span adjustments.
2) Shock and vibration shall not harm the transmitter or transducer.
3) Transmitters and transducers shall have a zeroing capability of readjusting the transmitter zero.

d. Accuracy requirements shall include the combined effects of linearity, hysteresis, repeatability, and the transmitter.

2. Output: Linear, proportional type over shielded cable pair, 4 - 20 mA or 0 – 10 Vdc signal.
3. Input Power: Low voltage, nominal 24 Vdc.

B. Temperature Sensors:

1. General: Temperature sensing elements shall have characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy. Sensor shall be UL 873 listed for temperature equipment.
2. Performance Requirements:

a. Thermistor:

1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
2) Temperature Differential Accuracy: Plus/minus 0.15 degrees F minimum.
3) Resolution: Plus/minus 0.2 degrees F minimum.
4) Heat Dissipation Constant: 2.7 mW per degree C.
5) Drift: 0.04 degree F after 10 years within temperature range.

b. RTD:

1) Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
2) Accuracy (All): Plus/minus 1 degree F minimum, unless otherwise noted below.

a) Room Sensor Accuracy: Plus/minus 0.5 degrees F minimum.
b) Chilled Water Accuracy: Plus/minus 0.5 degrees F minimum.
c) Temperature Differential Accuracy: Plus/minus 0.15 degrees F minimum.

3) Resolution: Plus/minus 0.2 degree F.
4) Drift: 0.04 degrees F after 10 years within temperature range.

c. Sensing Range:

1) Provide limited range sensors if required to sense the range expected for a respective point.

d. Wire Resistance:

1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.

2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.

3. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
4. Room Temperature Sensors:

a. Construct for surface or wall box, or enclosure with insulated backing suitable for exterior wall mounting.
b. Provide the following features:
1) Setpoint reset slide switch, dial wheel, or push-button interface with an adjustable temperature range.
2) Momentary override request push button for activation of after-hours operation.

5. Temperature Averaging Elements:

a. Use on duct sensors for ductwork 10 sq ft or larger.
b. Use averaging elements where prone to stratification with sensor length range between 16-22 ft.
c. Provide for all mixed air and heating coil discharge sensors regardless of duct size.

6. Insertion Elements:

a. Use in ducts not affected by temperature stratification or smaller than 10 sq ft.
b. Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches for pipe sizes greater than 4 inches.
c. Immersion Well Housing: 1/2 inch NPT brass or stainless steel. Stainless steel required for piping 6 inch and larger.

C. Humidity Sensors:

1. Elements: Accurate within 3 percent full range with linear output.

a. Accuracy shall include temperature effects.

2. Resolution: Plus/minus 1 percent.
3. Drift: Less than 1 percent full scale per year.
4. Sensing Range: 0 to 100 percent relative humidity.
5. Room Sensors: Provide housing with integral sensor. Housing shall be plastic, NEMA 250, Type 1. Provide with insulated backing suitable for exterior wall mounting.

a.

6. Duct Sensors: Insertion type probe with mounting plate. Housing shall be metal, NEMA 250, Type 1.
7. Outside Air Sensors: With element guard and mounting plate.

D. Pressure Transmitters:

1. Duct Static Pressure:

a. Type: Unidirectional, fixed range.
a. Performance Characteristics:

1) Accuracy: Plus/minus one percent of full scale.

2) Thermal Effects: Temperature compensated over a minimum 40 to 120 F range. Zero and span shift of plus/minus 0.06 percent or less of full scale per degree F.
3) Sensing Range: Select sensor so that the high end of the nominal sensor range is not less than 150 percent and not more than 300 percent of maximum expected input.
4) Long Term Thermal Stability: Plus/minus one percent full scale per year.

b. Construction:

1) Insertion or traverse type sensor suitable for use in flat oval, rectangular, and round duct configurations.
2) Insertion length selected as appropriate for duct size.
3) Traverse sensors shall have at least one pickup point every 6 inches.
4) Element: Variable capacitance sensing technology.
5) Housing: Fire retardant glass-filled polyester, brass, stainless steel, or aluminum.

2. Space Static Pressure:

a. Type: Bi-directional, fixed range.
b. Performance Characteristics:

1) Accuracy: Plus/minus 0.5 percent of full scale.
2) Thermal Effects: Temperature compensated over a minimum 40 to 120 F range. Zero and span shift of plus/minus 0.06 percent or less of full scale per degree F.
3) Sensing Range: Select sensor so that the high end of the nominal sensor range is not less than 150 percent and not more than 300 percent of maximum expected input.
4) Long Term Thermal Stability: Plus/minus 0.5 percent full scale per year.

c. Construction:

1) Sensing Port Wall Mounting: Wall plate with integral sensor, sized to fit standard single gang electrical box. Back of sensor plate fitted with union fitting for tubing connection.
2) Sensing Port Ceiling Mounting: Round plate with union fitting for tubing connection.
3) Sensor Element: Variable capacitance sensor technology.
4) Sensor Housing: Fire retardant glass-filled polyester, brass, stainless steel, or aluminum.

E. Equipment Operation Sensors:

1. Status Inputs for Airside Equipment:

a. Type: Fixed range differential pressure switch with adjustable setpoint.
b. Performance Characteristics:

1) Range: Not greater than two times the design fan static pressure.

c. Construction:

1) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered.
2) Provide Insertion tube for use in duct configurations. Insertion length selected as appropriate for duct size.
3) Contact Type: Single-pole, single-throw (SPST). Provide multiple poles or throw contacts to meet additional alarms required.

2. Status Inputs for Electric Motors:

a. Analog Current Transducer:

1) Type: Split core design, cable of being installed or removed without dismantling the primary bus cables.
2) Performance Characteristics:

a) Accuracy: Plus/minus 2 percent of selected range.
b) Range: Multi-range device, suitable for the amperage encountered with internal zero and span adjustment.
c) Analog output signal: Generate a proportional control signal relative to the amount of current through the primary bus cables.

3) Construction:

a) 24 V or Self-powered (passive).
b) Provide with integral command relay.
c) Device shall accept overcurrent up to twice its trip into range.
d) Enclosure: UL 94 approved thermoplastic, rated for V-0. No metal parts shall be exposed other than the terminals.

b. Binary Current Sensing Relay:

1) Type: Split core with current transformers, adjustable and set to 175 percent of rated motor current.
2) Self-powered (passive) with solid-state circuitry and a dry contact output.
3) Adjustable trip point.
4) Contact Type: Single-pole, double-throw (SPDT).
5) LED indicating the on or off status.
6) A conductor of the load shall be passed through the window of the device.
7) Device shall accept overcurrent up to twice its trip into range.

F. Carbon Dioxide Sensors:

1. General: Provide non-dispersive infrared (NDIR) CO2 sensors with integral transducers and linear output.

a. Linear, CO2 Concentration Range Display: 0 to 2000 ppm.
b. Full Scale Accuracy: Plus/minus 75 ppm at concentrations of both 600 and 1,000 ppm when measured at sea level at 77 degrees F.
c. Maximum Response Time: 1 minute.
d. Analog Output: 0-10 Vdc or 4-20 mA.
e. Rated Ambient Conditions:

1) Air Temperature: Range of 32 to 122 degrees F.
2) Relative Humidity: Range of 0 to 95 percent (non-condensing).

2. Calibration Characteristics:

a. Factory calibrated and certified by the manufacturer to require calibration not more frequently than once every 5 years.
b. Automatically compensating algorithm for sensor drift due to sensor degradation.
c. Sensor shall be temperature compensated throughout entire operating range.
d. Maximum Drift: 2 percent per year.

3. Construction:

a. Sensor Chamber: Non-corrosive material for neutral effect on carbon dioxide sample.
b. Duct Mounting: Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.
c. Wall/Surface Mounting: Construct for surface or wall box or enclosure suitable for wall mounting.

2.7 OUTPUT CONTROL DEVICES

A. Control Relays:

1. Provide relay with contact rating, configuration, and coil voltage that is suitable for the application.
2. Provide NEMA 1 enclosure when relay is not installed in a local control panel.
3. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator.
4. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus/minus 200 percent minimum from setpoint.

B. Fan Speed Controllers:

1. Solid-state model providing field-adjustable proportional control of motor speed. Equip with filtered circuit to eliminate radio interference.

2.8 POWER SUPPLIES

A. Reference Division 23 Section "Direct Digital Controls for HVAC" for DC power supply requirements.

B. Control power transformers shall meet NEMA/ANSI standards.

C. Control power transformers shall be UL listed for Class 2 current-limited service or provided with over-current protection on both primary and secondary circuits for Class 2 current-limited service.

D. Connected load on the transformer shall not exceed 80 percent of the transformer's rated capacity.

E. The core and windings shall be completely encased in a UL approved thermoplastic. No metal parts shall be exposed other than the terminals.

F. Performance Characteristics:

1. Accuracy: Plus/minus 1 percent at 5.0 A full scale output.

G. Provide a disconnect switch for each transformer.

2.9 THERMOSTATS

A. General:

1. Programmable, with the following features:

a. LCD or LED display screen.
b. Button our touch-screen Interface.
c. 7-day programmable scheduling.
d. Temperature information display.
e. Setpoint display and adjust.
f. Operation mode display and adjust.
g.
h. Override.
i. Remote temperature sensor interface terminal.
j. Lockout.

2. Performance Requirements:

a. Accuracy: Plus/minus 1.0 degree F minimum.
b. Resolution: Plus/minus 0.2 degrees F.
c. Range:

1) Operating Temperature: 32 degrees F to 122 degrees F minimum.
2) Operating Humidity: 0 percent to 95 percent relative humidity, non-condensing.
3) Setpoint Control:

a) Cooling: 54 degrees to 100 degrees F.
b) Heating: 40 degrees to 90 degrees F.

d. Multi-stage as required to match unit cooling and heating stages scheduled on the drawings.

B. Electric Room Thermostats:

1. Type: 24 volts, two position switch, programmable with setback/setup temperature control.
2. Covers: Locking with set point adjustment and indication.
3. Setpoint functional range: 45 degrees F to 90 degrees F.

C. Room Thermostat Accessories:

1. Thermostat Covers: Plastic.
2. Insulating Bases: For thermostats located on exterior walls.
3.
4. Adjusting Key: As required for device.
5. Aspirating Boxes: Where indicated for thermostats requiring flush installation.
6. Integrated sensors: At the contractor's option, the following sensors may be provided with the thermostat in a single device. Refer to the drawings where additional sensors are required. Refer to "Input/Output Sensors" section of this specification for language governing performance of the integrated sensors.

a. Occupancy sensor.
b. Humidity sensor.

c. Carbon dioxide sensor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.2 EXISTING EQUIPMENT

A. Wiring: The contractor may reuse any abandoned wires. The integrity of the wire and its proper applications to the installation are the responsibility of the contractor. The wire shall be properly identified and tested. Unused or redundant wiring that remains in place shall be identified as such.

B. Local Control Panels: The contractor may reuse any existing local control panels to locate new equipment. All redundant equipment within these panels shall be removed. Panel face cover shall be patched to fill all holes caused by removal of unused equipment or replaced with new.

C. Repair: Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, notify the engineer immediately.

D. Temperature sensor wells: The contractor may reuse any existing wells in piping for temperature sensors. The wells shall be modified as required for proper fit of new sensors.

E. Indicator Gauges: Where these devices remain and are not removed, recalibrate and ensure reasonable accuracy.

F. Unless otherwise noted, salvage, recondition, and reuse the following devices:

1. Room thermostats.
2. Electronic sensors and transmitters.
3. Controller and auxiliary electronic devices.
4. Damper actuators, linkages, and appurtenances.

G. Patch holes and finish to match existing walls.

3.3 INSTALLATION

A. Cooperate with other contractors performing work on this project as necessary to achieve a complete and coordinated installation. Each Contractor shall consult the Drawings and Specifications for all trades to determine the nature and extent of others work.

B. General Workmanship:

1. Install equipment, piping, and wiring/raceway parallel to building lines wherever possible.
2. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
3. Install all equipment in readily accessible locations.
4. All installations shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
5. Install all products in accordance with manufacturer's instructions.

C. Sensors:

1. Mount sensors rigidly and adequately for the environment within which the sensor operates.
2. Provide thermistor type temperature sensors for temperature ranges between minus 30 degrees F to 230 degrees F. Provide RTD type temperature sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing. Coordinate installation of room/space sensors with architect and other trades to ensure a neat and orderly installation.
4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
5. Sensors used in mixing plenums and hot and cold decks shall be of averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
6. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
7. Install temperature, humidity, and smoke detectors for both supply air and return air applications a minimum of 10'-0" downstream or upstream of the air handling unit and prior to any branch duct takeoffs.
8. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
9. Install outdoor air temperature sensors on north wall, complete with sun shield where shown on the plans. If not shown, locate sensors in an accessible location, a minimum of 15 feet away from exhaust or relief air locations.
10. Differential air static pressure.

    a. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
    b. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building. Pipe the high-pressure port to a location suitable to sense common building pressure or as indicated on the drawings.

1) Panel mount the transducer adjacent to its associated building automation system controller. Provide an independent manometer gauge next to transducer for calibration.

c. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
d. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
e. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

11. Verify location and mounting height of thermostats, humidistats, and exposed control sensors with plans and room details before installation. Align with adjacent lighting switches and humidistats.

a. Install devices to meet ADA requirements unless otherwise noted on the plans.

12. Mount freeze protection thermostats using flanges and element holders.

a. Install thermostat completely across the surface the thermostat serves.

13. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
14. Provide separable sockets for liquids and flanges for air bulb elements.
15. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
16. Install shutoff valves in the high and low pressure reference lines connecting to hydronic pressure sensors and switches. Install a shunt valve across the high and low reference pressure ports for servicing. Valves may be ordered as an integral option with the sensor.

D. Control Dampers:

1. Install dampers with extruded aluminum or stainless steel frames and blades in corrosive environments and areas with high humidity.
2. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
3. Clearance:

a. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
b. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

4. Service Access:

a. Dampers and actuators shall be accessible for visual inspection and service.
b. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Division 23 Section, "Air Duct Accessories.".

5. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting.

6. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
7. Provide mixing dampers of parallel blade construction arranged to mix streams. Where shown on the drawings, provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.
8. Provide isolation (two position) dampers of parallel blade construction.
9. Provide opposed blade damper configuration for all other applications.
10. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
11. After installation of low-leakage dampers and seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

E. Operators:

1. Mount and link control damper actuators according to manufacturer's instructions.

   a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, and then tighten the linkage.
   b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   c. Provide all mounting hardware and linkages for actuator installation.

2. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degree available for tightening the damper seals.

F. Control Panels:

1. Install control panels where shown on the drawings and where required to house controllers for the controlled systems and equipment.
2. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
3. Coordinate 120V power requirements with Division 26 to panels used for the building automation system and transformers for low voltage power to controllers.

G. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

H. Provide an insulation standoff on control devices, cables, and other items that do not require flush mounting to ductwork, piping, or equipment.

3.4 MAINTENANCE

A. Refer to Division 01 closeout requirements for additional requirements relating to maintenance service.

B. Provide service and maintenance of control system for one year from Date of Substantial Completion.

C. Provide complete service of controls systems, including call backs, and submit written report of each service call.

3.5 STARTUP AND DEMONSTRATION

A. Control Dampers:

1. Stroke and adjust control valves and dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
2. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
3. For control valves and dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
4. Verify that all two-position dampers and valves operate properly and that the normal positions are correct.
5. Verify that all modulating dampers and valves are functional, that the start and span are correct, that direction and normal positions are correct, and that they achieve proper closure.

3.6 DAMPER SCHEDULE

SERVICE	RUSKIN MODEL	MATERIAL
Outside, Exhaust and Relief Air Control, Stairway and Shaft Vents	CD-50	Aluminum
Control	SD-60	Galvanized Steel
All Other	CD-356	Galvanized Steel

3.7 DAMPER OPERATOR VOLTAGE SCHEDULE

SERVICE	VOLTAGE
Interlocked with HVAC fans	120V
Multi-section dampers	120V
Large dampers (> 60 inches in any dimension)	120V
All other operators control wiring	24V

1. Note: Coordinate with Division 26 if 120V power is required for operator to achieve appropriate torque requirements for damper actuation.

END OF SECTION

SECTION 230923 - DIRECT-DIGITAL CONTROL FOR HVAC

PART 1 - GENERAL

1.1 INSTRUCTIONS TO BIDDERS

A. The system specified in this section shall be WebCtrl manufactured by Automated Logic Corporation for interface with the District's existing building automation controls and service infrastructure. Contact Controls Service Co., Inc. (816)-600-5800.

1.2 SECTION INCLUDES

A. System Description.

B. Operator Interface.

C. Controllers.

D. Electrical Control Power Wiring and Low Voltage Wiring.

E. Local Area Network.

F. System Software.

G. Controller Software.

1.3 REFERENCE STANDARDS

A. ANSI/CEA 709.1.D - Control Network Protocol Specification; 2014.

B. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; most current edition.

C. IEEE C37.90.1 – IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus, most current edition.

D. IEEE C62.41.2 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits, most current edition.

E. ISO 7498 – Information Processing Systems – Open System Interconnection – Basis Reference Model, International Standards Organization, most current edition.

F. NEMA – National Electrical Manufacturers Association.

G. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.5 DEFINITIONS

A. ASC: Application Specific Controller. Examples include controllers for specific applications (e.g., FCU, VAV box, etc.) that can be configured through any network services software.

A. ATU: Air Terminal Unit (e.g., VAV boxes, fan-powered boxes, fan coil units).

B. BAS: Building Automation System.

C. BTL: BACnet Testing Laboratories. Third party independent testing and listing program for devices which have been tested according to ASHRAE Standard 135.

D. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operations

E. DDC: Direct Digital Control.

F. EMT: Electrical Metallic Tubing

G. High voltage: 50 volts or higher.

H. IP: Internet Protocol.

I. LAN: Local Area Network.

J. VLAN: Virtual Local Area Network.

K. Low voltage: Below 50 volts.

L. OSI: Open System Interconnection

M. PC: Personal Computer.

N. PICS: Protocol Implementation Conformance Statement.

O. Point: Point is a generic term used to describe a single item of information in a BAS. Points may be further described as input, output, digital, binary, discrete, analog, modulating, internal, external, virtual or global. Each unique point used by digital controllers, or in a BAS, is typically identified by an address.

1.6 CONTRACTOR RESPONSIBILITIES

A. Reference the following sections for additional contractor responsibilities and coordination:

1. Division 23 Section "Electrical Coordination for Mechanical Equipment."

2. Division 23 Section "Commissioning for HVAC."
3. Division 23 Section "Instrumentation and Control Devices for HVAC."

B. Reference Part 3 for additional electrical contractor responsibilities for BAS controls.

1.7 SUBMITTALS

A. Refer to Division 01 and Division 23 Section "General Mechanical Requirements" for submittal procedures.

B. General:

1. The drawings and specifications are not intended to show all details. The BAS contractor shall secure satisfactory information before submitting the proposal and include in the proposal a sum sufficient to cover all items of labor and material required for the complete installation for the devices and system described.
1. Inform Engineer in writing of any deviation in the exhibits submitted from the requirements of the drawings, specifications, and sequences of operations.

C. Product Data:

1. Submit manufacturer technical data for each system component and software module required for a complete installation.
2. Indicate dimensions, weights, and enclosure construction for all BAS distributed controllers.
2. Submit technical data on all new software supplied including description of functions performed by software and location within the system where software shall reside. Include all software licensing agreements.
3. Submit the PICS for each BACnet device used in the BAS.

D. Power and Communication Wiring Transient Protection:

1. Submit catalog data sheets providing evidence that all BAS products offered by the manufacturer are tested and comply with IEEE C62.41.2.
2. Testing shall include power and communication trunk wiring.
3. Compliance with IEEE C62.41.2 shall imply conformance with IEEE C37.90.1based on the stated position of ANSI and IEEE.

E. Shop Drawings:

1. Submit a trunk cable schematic showing locations of all programmable control units, controllers, and workstations, with associated network wiring.

    a. Indicate equipment served by each controller on the diagram.
    b. Indicate switches, power requirements to each controller, and daisy chained controllers.

3. Submit detailed schematic control drawings for each controlled device and equipment.

    c. Reference all control components to manufacturer make and model number.
    d. Include all control and power wiring with termination point (controller and terminal number).
    e. Include clearly indicated and written sequences of operation referenced to specific control components (e.g., "shall modulate valve V-3").

f. Include default position (e.g., N.O., N.C., etc.) for all components where applicable.
g. Clearly differentiate between existing components and new components.
a. Include detailed wiring diagrams showing methods of connections to VFDs, motor starters, energy meters, and all other devices, and all other field wiring necessary for system installation.
b. The use of "typicals" will be allowed where appropriate.

2. Submit detailed drawings for each individual BAS distributed controller.

a. Include controller identification.
b. Include components included in the controller.
c. Include numbering of terminals and communications ports.
d. List connected data points, including connected control unit and input device.
e. Include type of cable connected to each terminal port.
f. Identify specific field devices wired to each terminal including identification of each field device and application.
g. Clearly differentiate between existing controllers and new controllers.
h. Indicate source (electrical panel ID) of 120V power to each panel to which 120V power is connected.
i. Indicate method of connecting controller to equipment supplied by others and to existing communications networks.
j. Indicate device instance and network number.

3. Submit floor plans that indicate the following:

a. Location of all new BAS distributed controllers and control panels.
b. Routing of all new building level network communications wiring not located in mechanical and electrical rooms.
c. Routing of wiring to controllers, sensors, and control points not located in mechanical and electrical rooms.
d. Location of building system connection to Owner's campus wide data network.

4. Submit methods and materials used to integrate into existing networks.
5. All control drawings and schematics shall be generated using AutoCAD software or equivalent. All project drawings shall be supplied to the Owner in a format as desired by the Owner upon project completion.
4. Submit system identification nomenclature.

a. Nomenclature shall be consistent throughout the network and consistent with any existing networks that are integrated. If not defined, nomenclature shall be similar to the point names shown on the drawings.
b. Control device instance name and ID number shall be unique within the network.
c. Network number shall be unique for each unique electrical segment in the BAS.

6. Indicate system graphics indicating monitored systems, data (connected and calculated) and operator notations.

a. Submit example graphic visualizations and screenshots for the BAS. At a minimum, submit examples for major HVAC equipment components, including chillers, boilers, air handling units, fan coil units, heat pumps, fans, etc.
b. Font size and type shall be manufacturer standard.
c. Provide graphics demonstration package in a format as desired by the Owner.

7. Indicate description and sequence of operation of operating, user, and application software.

F. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

G. Manufacturer's qualification statement.

H. Installer's qualification statement.

I. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.

1. Revise shop drawings to reflect actual installation and operating sequences.
2. Include submittals data in final "Record Documents" form.
3. All additions or changes to the BAS during the course of construction shall be reflected upon the drawings and submitted to the Engineer before project close-out.

J. Testing and Commissioning Reports and Checklists: Submit completed versions of all reports and checklists, along with all trend logs, used to meet the requirements of Part 3, Startup and Demonstration.

K. Operation and Maintenance Data:

1. Include maintenance data and recommended spare parts list for digital control equipment and control components.
2. Include trouble-shooting maintenance guides.
3. Include interconnection wiring diagrams showing complete field installed systems with identified and numbered system components and devices.
4. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
5. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
6. Include a maintenance manual which contains the information listed above, product data, shop drawings, final software code for sequences of operation and maintenance data in accordance with requirements of Division 01.
7. Include logbook for documentation of software updates and patches applied BAS for the time period included in the software licensing agreement.
8. Provide names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

L. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

M. Maintenance Materials:

1. Refer to Division 01 for additional provisions.

1.8 QUALITY ASSURANCE

A. Perform work in accordance with NFPA 70.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

C. BACnet devices used in the BAS shall be BTL listed according to its device profile.

D. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

E. Installer Qualifications: Company specializing in performing the work of the type specified and with minimum documented experience as follows:

1. All personnel of the BAS Contractor shall have a minimum of three years of experience within their appropriate trades.
2. All subcontractors utilized by the BAS Contractor shall have a minimum of five years experience within their appropriate trades.

F. Additional BAS Contractor Requirements:

1. Personnel, Coverage and Response Capabilities: The BAS Contractor shall have a fully staffed office with service technicians and systems engineers within a 50 mile radius of the project location.
2. Emergency Service: The BAS Contractor shall have an established 24 hour emergency service organization. A dedicated telephone number shall be provided to the Owner for requesting emergency service. A maximum of four hour, electronic service technician on sight, response time shall be guaranteed by the BAS Contractor.
3. Parts Stocking: The BAS Contractor shall have an independently verifiable inventory of electronic service parts. This electronic service parts inventory must have a worth of at least $100,000 per year over the last five years.

1.9 WARRANTY

A. Refer to Division 01 for additional project warranty requirements.

B. Labor and materials for the BAS specified shall be warranted free from defects in workmanship and material for a period of 2 years after Substantial Completion and system acceptance.

C. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.

D. All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up. If the work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start data and period.

E. 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.

F. Contractor shall maintain and provide a standard 12 month warranty for any existing equipment, wiring, and controllers that are selected to be reused for the project. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of system commissioning.

G. Provide five year manufacturer's warranty for field programmable micro-processor based units.

H. Special warranty on instrumentation:

1. All instrumentation shall be covered by manufacturer's transferable one-year "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

1.10 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:

1. Limiting use of software to equipment provided under these specifications.
2. Limiting copying.
3. Preserving confidentiality.
4. Prohibiting transfer to a third party.

B. Software provider shall provide software updates and patches to the BAS as part of the software licensing agreement as the updates and patches are released. If any security vulnerabilities are discovered by the provider, the provider shall notify the client within five business days.

C. Ownership of Proprietary Material: Project-specific software and documentation shall become Owner's property upon project completion. This includes, but is not limited to the following:

1. Graphics.
2. Record drawings.
3. Database.
4. Application programming code.
5. Documentation.

PART 2 - PRODUCTS

2.1 OWNER FURNISHED PRODUCTS

A. New Products: None/Not Applicable

B. Existing Products: Owner desires to re-use existing sensors and cards where possible. Provide a clear indication in the shop drawing submittals of which devices are existing to remain or be re-used.

2.2 MANUFACTURERS

A. Corporate Edition Products: The following manufacturers and product lines shall be manufacturer's most current vintage and of open protocol design. Corporate editions shall be based on manufacturer developed software.

1. Automated Logic, WebCtrl.

B. The above list of manufacturers applies to operator workstation software, controller software, the custom application programming language, building controllers, custom application controllers, and application specific controllers. All other products specified under Division 23 Section "Instrumentation and Control Devices for HVAC" need not be manufactured by the above manufacturers.

2.3 SYSTEM DESCRIPTION

A. General:

1. The BAS shall consist of all necessary hardware and software to perform the control sequences of operation as called for in the Specifications and Drawings. Contractor shall install and commission all necessary devices to ensure a reliable and stable network.
2. System design is based on a distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
3. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
4. The BAS shall be capable of integrating multiple devices, sensors, and functions from multiple control vendors into a common front end, including equipment supervision and control, alarm management, energy management, and trend data collection.
5. The BAS shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASC's, and operator devices.
6. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

B. Local Area Network:
1. The BAS shall be set up using a VLAN connection into the Owner's internet or enterprise intranet. The VLAN shall be digitally separate from all other networks and shall share a common physical cabling backbone. Coordinate with the Owner to configure Ethernet and IP router switches to accommodate the VLAN.

C. Network Architecture: The BAS network architecture shall be based upon the OSI basic reference model in accordance with ISO 7498.

1. Application/Network Layer:

a. BACnet protocol complying with ASHRAE Standard 135.
2. Physical/Data Link Layer:

a. Hard-wired type:

1) Ethernet according to ISO 8802-2 protocol.
2) EIA-485 Twisted Cable Pair according to Master Slave/Token-Passing (MS/TP) protocol.
3. Communication between operator workstation(s) and building controller(s):

a. Ethernet.
4. Communication between building controller(s) and application specific and custom application controllers:

a. MS/TP.
b. PTP.

D. Web Services Enabled Network:

1. The network shall be capable of being accessed remotely over the internet via a virtual link according to Internet Protocol.
2. System software shall be based on a client/server architecture, designed around the open standards of web technology. The BAS server shall be accessed using a web browser

over the BAS network, Owner's LAN, and remotely over the Internet (through the Owner's LAN).

3. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming. Connection shall be browser agnostic.
4. Software applications shall be designed and optimized for hand-held device interface (e.g., tablets, smart phones, etc.). Interface shall grant visibility and control access, at a minimum, to the following data: Summary, Alarm, Setpoints, Status, Schedule, and Trending.

E. Network Integration:

1. The BAS network shall be integrated with other automation networks controlled by the Owner. Coordinate with the Owner's information technology (IT) department for networks that shall be integrated.
2. Provide gateways or other integration devices across networks with different communication protocol to provide a single network visibility and interoperability at the operator workstation. Coordinate communication protocol with each automation system specified.
3. Interoperable networks shall be capable of sharing all point and point information across networks to a single BAS front end.
4. Interoperable networks shall be capable of automatically downloading application program changes.
5. For integrated networks that cannot automatically download application program changes, provide a link to the Controller Manual Download Schedule, as defined in the submittals section of Part 1 on the BAS front end summary page
6. Integrate the following networks:
   a. Lighting control systems (where indicated to be required by owner).

F. Network Interoperability:

1. Provide communication between control units over local area network (LAN).
2. Communication services over the LAN shall result in operator interface and value passing that is transparent to the network architecture as follows:

   a. Connection of an operator interface device to any one controller on the network shall allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the network.
   b. All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the network. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform network value passing.

2.4 OPERATOR INTERFACE

A. General:

1. The Operator Interface shall provide overall BAS supervision and system software interface. Communications from the workstation shall be executed directly to and between the integration level building controllers and field level controllers.

2. The operator interface shall be capable of command entry, information and alarm management, database management, access of all system data, and be independent of hardware technology.
3. Database Save/Restore/Back-Up:

    a. Back-up copies of all Building Controller and ASC data as well as mass storage for trend logs shall be stored in the mass storage device designated by the Owner.

1.2 CONTROLLERS

B. Building Controllers

1. General:

    a. Input Power Requirements: 24Vac.
    b. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
    c. Provide sufficient memory to support controller's operating system, database, and programming requirements.
    d. Share data between networked controllers.
    e. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
    f. Utilize real-time clock for scheduling.
    g. Continuously check processor status and memory circuits for abnormal operation.
    h. Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
    i. Communication with other network devices to be based on assigned protocol.
    j. Monitor the status of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

2. Communication:

    a. Perform routing when connected to a network of custom application and application specific controllers.
    b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

        1) Port shall be USB type.

3. Anticipated Environmental Ambient Conditions:

    a. Outdoors and/or in Wet Ambient Conditions:

        1) Mount within NEMA 4X waterproof enclosures.
        2) Rated for operation at 40 to 150 degrees F and 95 percent RH, non-condensing.

    b. Conditioned Space:

        1) Mount within NEMA 1 dustproof enclosures.
        2) Rated for operation at 32 to 120 degrees F.
4. Provisions for Serviceability:

a. Diagnostic LEDs for power, communication, and processor.
b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:

a. Maintain operation at 90 to 110 percent of nominal voltage rating.
b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Upon restoration of normal power, the controller shall automatically resume full operation without manual intervention.
d. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

7. Surge and Transient Protection:

a. Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard C62.41.2.
b. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

C. Custom Application Controllers

1. General:

a. Input Power Requirements: 24Vac.
b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
c. Share data between networked, microprocessor based controllers.
d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
e. Utilize real-time clock for scheduling.
f. Continuously check processor status and memory circuits for abnormal operation.
g. Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
h. Communication with other network devices to be based on assigned protocol.
i. Monitor the status of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

2. Communication:

a. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:

a. Outdoors and/or in Wet Ambient Conditions:

1) Mount within NEMA 4X waterproof enclosures.
2) Rated for operation at 40 to 150 degrees F and 95 percent RH, non-condensing.

b. Conditioned Space:

1) Mount within NEMA 1 dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F.

4. Provisions for Serviceability:

a. Diagnostic LEDs for power, communication, and processor.
b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:

a. Maintain operation at 90 to 110 percent of nominal voltage rating.
b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Upon restoration of normal power, the Digital Panel shall automatically resume full operation without manual intervention.
d. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

7. Surge and Transient Protection:

a. Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard C62.41.2.
b. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

D. Application Specific Controllers

1. General:

a. Input Power Requirements: 24Vac.
b. Not fully user programmable, microprocessor based controllers dedicated to control specific equipment.
c. Customized for operation within the confines of equipment served.
d. Provide sufficient memory to support controller's operating system, database, and programming requirements.
e. Communication with other network devices to be based on assigned protocol.

1) Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

f. Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.

2. Communication:

a. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:

a. Outdoors and/or in Wet Ambient Conditions:

1) Mount within NEMA 4X waterproof enclosures.
2) Rated for operation at 40 to 150 degrees F.

b. Conditioned Space:

1) Mount within NEMA 1 dustproof enclosures.
2) Rated for operation at 32 to 120 degrees F and 95 percent RH, non-condensing.

4. Provisions for Serviceability:

a. Diagnostic LEDs for power, communication, and processor.
b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory. In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:

a. Maintain operation at 90 to 110 percent of nominal voltage rating.
b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Upon restoration of normal power, the controller shall automatically resume full operation without manual intervention.
d. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

7. Surge and Transient Protection:

a. Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard C62.41.2.
b. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

E. Input/Output Interface

1. Hardwired inputs and outputs shall tie into the BAS through building, custom application, or application specific controllers.
2. All Input/Output Points:

a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
c. Universal-type inputs or outputs configurable between binary and analog are acceptable.

3. Binary Inputs:

a. Allow monitoring of On/Off signals from remote devices.
b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
c. Sense dry contact closure with power provided only by the controller.

4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:

    a. Allow for monitoring of low voltage 0 to 10 Vdc, 4 to 20 mA current, or resistance signals (thermistor, RTD).
    b. Compatible with and field configurable to commonly available sensing devices.

6. Binary Outputs:

    a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
    b. Outputs provided with three position (On/Off/Auto) override switches.
    c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.

7. Analog Outputs:

    a. Monitoring signal provides a 0 to 10 Vdc or a 4 to 20 mA output signal for end device control.
    b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
    c. Drift to not exceed 0.4 percent of range per year.

8. Tri State Outputs:

    a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
    b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:

        1) VAV terminal units.
        2) Duct mounted heating coils.
        3) Zone dampers.
        4) Radiant devices.

    c. Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.5 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Power Wiring: Copper wiring, plenum cable, and raceways shall be as specified in the applicable section of Division 26.

B. Power and Communication Wiring Transient Protection:

1. Comply with IEEE C62.41.2.
2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection required.
3. Communication circuitry, input/output circuitry, and communication unit shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations.

a. For systems not complying with this requirement, provide equivalent protection external to the automatic temperature control system controller. Protection shall be provided for the individual communications and input/output terminations for each automatic temperature control system controller.
b. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

C. Power Supplies:

1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
2. Limit connected loads to 80 percent of rated capacity.
3. Match DC power supply to current output and voltage requirements.
4. Supplies shall be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
7. Operational Ambient Conditions: 32 to 120 degrees F.
8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
9. Line voltage units UL recognized and CSA approved.

D. Power Line Filtering:

1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
2. Minimum surge protection attributes:

a. Dielectric strength of 1000 volts minimum.
b. Response time of 10 nanoseconds or less.
c. Transverse mode noise attenuation of 65 dB or greater.
d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

E. Input/Output Control Wiring

1. Control wiring shall be sized to accommodate the voltage drop associated with the distance between the control device and the controller. Minimum size shall be as specified herein.
2. In all communication conduits, provide one spare twisted pair to be installed, tagged and labeled at each end.
3. Control wiring not installed in conduit shall be UL rated for plenum installation.
4. Ethernet control wiring shall be fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.
5. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gauge.
6. Other analog inputs shall be a minimum of number 22 gauge, twisted, shielded.
7. Binary control function wiring shall be a minimum of number 18 gauge.
8. Analog output control functions shall be a minimum of number 22 gauge, twisted, shielded.
9. Binary input wiring shall be a minimum of number 22 gauge, twisted, shielded.
10. Thermistors shall be equipped with the manufacturer's calibrated lead wiring.
11. 120V control wiring shall be #14 THHN in 3/4 inch conduit. Provide 20% fill extra wire in each conduit.

F. Splices: Splices in shielded cables shall consist of terminations and the use of shielded cable couplers that maintain the integrity of the shielding.

G. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: EMT with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

H. Relays

1. Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
2. Solid State Relays (SSR):

a. Input/output isolation: Greater than 10 E^9 ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz.
b. Contact Life: 10 x 10 E^6 operations or greater.
c. Ambient Temperature Range: Minus 20 to +140 degrees F.
d. Input impedance: Not be less than 500 ohms.
e. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.

3. Contactors:

a. Type: Single coil, electrically operated, mechanically held, double-break, silver-to-silver type protected by arcing contacts.
b. Positive locking shall be obtained without the use of hooks, latches, or semi permanent magnets.
c. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

2.6 SYSTEM SOFTWARE

A. General:

1. Provide all necessary system software to form a complete operating system for all operator interface devices.
2. System software shall integrate with all controller software and allow management of software applications at the operator workstation.
3. System software display language: English.

B. Device Profile: BACnet devices shall Conform to the following device profiles as specified in ASHRAE/ANSI 135 BACnet Annex L:

1. Operator workstation: BACnet Advanced Workstation (B-AWS).

2. Building Controller: BACnet Building Controller (B-C).
3. Advanced Application Controller: BACnet Advanced Application Controller (B-AAC).
4. Application Specific Controller: BACnet Application Specific Controller (B-ASC).

C. Software Programming:

1. Provide programming for the system and adhere to the sequences of operation provided. Provide actions for all possible situations. All other system programming necessary for the operation of the system shall be provided by the Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Provide text-based, graphic-based, and parameter-based programming where appropriate.

D. Operating System:

1. Concurrent, multi-tasking capability.
2. Common Software Applications Supported:

    a. Microsoft Windows and Microsoft Office Suite.
    b. Open platform compatible database: Microsoft Access, Oracle Database, IBM Analytics, or other SQL database software. Proprietary databases shall not be acceptable.

3. Acceptable Operating Systems: Most recent version of operating system.

E. System Graphics:

1. Color type, saved in an industry-standard format such as BMP, JPEG, PNG, or GIF.
2. Allow simultaneous display for comparison and monitoring of system status.
3. Web based graphics shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X, Java Virtual Machine, and Adobe Flash).
4. Animate displayed objects by shifting image files of objects based on object status.
5. Functionality: Provide method for operator with password to perform the following:

    a. Move between, change size, and change location of graphic displays.
    b. Modify on-line.
    c. View a summary of the most important data for each controlled zone or piece of equipment.
    d. View a summary of the most important global data for the project, including but not limited to date, day of week, time, outdoor dry bulb temperature, and humidity.
    e. Use point-and-click navigation between graphic screens.
    f. Edit setpoints and other specified parameters.
    a. Edit equipment names and numbers.
    b. Edit room names and numbers.
    g. Indicate areas or equipment in an alarm condition using color or other visual indicator.
    h. Add, delete, or change dynamic objects consisting of:

        1) Analog and binary values.
        2) Dynamic text.
        3) Static text.
        4) Animation files.

i. Display graphic file, text, and dynamic object data together on a single graphic. Display all measured and commanded data, setpoints, calculated values, and input and output control points with appropriate engineering units associated with each system schematic.
j. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
k. Dynamic Data Displays shall be capable of including point data from multiple ASC's.

6. Include at least one graphic for each of the following:

a. Each piece of equipment.
b. Occupied zone.
c. Hydronic system (chilled water, condenser water, hot water, steam, heat pump, etc.)
d. Floor plan displays of the building. Indicate summary conditions for each floor.
e. Indicate thermal comfort on floor plan using dynamic colors to represent zone temperature relative to zone setpoint.

2. Graphic Tree Structure:

f. Structure graphic system tree to allow access to individual graphic screens from a macro to a micro level.
g. Allow each level of graphic direct access to the graphic screen above and below the graphic screen in the system tree.
h. Allow direct access to the main summary graphic screen/map from any individual graphic screen.

7. Sequence of Operation Graphics:

a. Display the complete Sequence of Operation or include a link to a separate text file that contains the sequence of operation, as submitted by the Contractor and approved by the Engineer with each system schematic view. The Sequence of Operation text shall be in a separate frame above, below, or to the side of the graphic as appropriate for the graphic size and content.

8. Custom Graphics Generation Package:

a. Allow operator to create, delete, modify, and save custom graphic files and displays. File format of graphics shall be compatible with BAS software.
b. Web-based Graphics: HTML graphics to support web browser compatible formats.
c. The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard components with which custom graphics may be built. Standard components include but are not limited to

1) Air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.).
2) Complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.).
3) Hydronic system components (e.g., chillers, boilers, pumps, piping, valves, etc.).
4) Electrical symbols.

d. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following

1) Define symbols.

2) Position and size symbols.
3) Define background screens.
4) Define connecting lines and curves.
5) Locate, orient and size descriptive text.
6) Define and display colors for all elements.
7) Establish correlation between symbols or text and associated system points or other displays.
8) Capture or convert graphics from AutoCAD.

e. Graphical displays shall be capable of representing a group of objects. Groups shall be capable of representing any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the building.

3. Standard HVAC Graphics Library: Furnish a complete library of standard HVAC equipment graphics and standard symbols for ancillary equipment in a file format compatible with the graphics generation package program. Graphics shall include, but not be limited to, the following:

a. HVAC Equipment:

1) Chillers.
2) Boilers.
3) Air Handlers.
4) Terminal HVAC Units.
5) Fan Coil Units.
6) Unit Ventilators.
7) Heat Exchangers.

b. Ancillary Equipment:

1) Fans.
2) Pumps.
3) Coils.
4) Valves.
5) Piping.
6) Dampers.
7) Ductwork.

F. Workstation System Applications:

1. General Application Functions:

a. All applications shall be capable of being executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization.
b. Allow BAS configuration and future changes or additions by operators with password protection.
c. Execute configured processes defined by the user to automatically perform calculations and control routines.
d. Process Inputs and Variables: It shall be possible to use any of the following in a configured process:

1) Any system-measured point data or status
2) Any calculated data
3) Any results from other processes

4) Boolean logic operators (and, or)

e. Process Triggers: Configured processes may be triggered based on any combination of the following:

1) Time of day
2) Calendar Date
3) Other processes
4) Events (e.g., point alarms)

f. Data Access: A single process shall be able to incorporate measured or calculated data from any and all other ASC's. In addition, a single process shall be able to issue commands to points in any and all other ASC's on the local network.

2. Network Configuration:

a. Allow for configuration of the BAS network.
b. Provide alarm when a break in communication between devices is detected.
c. Enable the operator to add, delete, or modify the following:

1) Building controllers and ASC's.
2) Points of any type, point parameters, and tuning constants.

d. Provide automatic reconfiguration if any station is added or lost.

3. Save and Restore:

a. Automatic System Database Save and Restore Functions:

1) Store current database copy of each Building Controller on hard disk or server.
2) Backup database on a user adjustable frequency basis. Default frequency shall be monthly.
3) Automatically update upon change in any system panel.
4) In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.

b. Manual System Database Save and Restore Functions by Operator with Password Clearance:

1) Save database from any system panel.
2) Clear a panel database.
3) Initiate a download of a specified database to any system panel.

4. On-line Help:

a. Include context-sensitive system to assist operator in operation and editing.
b. Include topics available for all applications.
c. Include relevant screen data provided for particular screen display.
d. Include additional help via hypertext.

5. Security:

a. Require user name and password for Operator log-on to view, edit, add, or delete data.
b. Include selectable system security for each operator. Support a minimum of five levels of access:

1) Level 1 = Read-only data access and display.
2) Level 2 = Level 1 + scheduling.
3) Level 3 = Level 2 + operator overrides and commands.
4) Level 4 = Level 3 + database generation and modification.
5) Level 5 = Level 4 + Audit trail management.
6) Operators shall be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device shall be limited to only the items defined as accessible for the user.
7) Support a minimum of 4 passwords at each Building Controller.

c. Allow system supervisor to set passwords and security levels for all other operators.
d. Allow operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
e. Include automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
f. Store all system security data in encrypted format.
g. Log all user actions and store data for audit with permission access by system administrator only.

1) Include the modified system.
2) Include the value modified.
3) Include the time of modification.

6. System Diagnostics:

a. Operations Automatically Monitored:

1) Workstations.
2) Printers.
3) Network connections.
4) Building management panels.
5) Controllers.

b. Device failure is annunciated to the operator.

7. Alarm Management:

a. Allow alarm prioritizing to minimize nuisance reporting and to speed operator response to critical alarms.

1) Provide a minimum of three, user definable priority levels.
2) Enable users to manually inhibit alarm reporting for each point.
3) Enable users to manually inhibit nuisance alarm reporting for maintenance or repair work that is scheduled to be performed.
4) Enable user to define conditions under which point changes need to be acknowledged by an operator, and/or logged for analysis at a later date.
5) Allow alarm prioritization to lock out or circumvent other alarms that may be generated as a result of primary alarm.

b. Prohibit interference with the ability of the system software to report alarms by either operator activity at the local I/O device, or communications with other system controllers on the network.
c. Allow all system objects that are configurable to "alarm in" and "alarm out" of normal state.
d. Configurable Objects:

1) Alarm limits.
2) Alarm limit differentials.
3) States.
4) Reactions for each object.
5) Alarm delay.

e. Alarm Messages:

1) Descriptor: English language. Acronyms or mnemonics for objects in alarm are not acceptable.
2) Recognizable Features:

a) Source.
b) Location.
c) Nature.
d) Time and Date.
e) Alarm message box to more fully describe the alarm condition or direct operator response.
f) Each Alarm messages shall be assignable to any point in the BAS. Alarm messages shall be assignable to multiple points.
a) Notification of an alarm override.

f. Configurable Alarm Reactions by Workstation and Time of Day:

1) Logging.
2) Printing.
3) Starting programs.
4) Displaying messages.
5) Phone text message.
6) Email.
7) Providing audible annunciation.
8) Displaying specific system graphics.

8. Custom Trend Logs:

a. Maintain trend information for minimum 365 days.
b. Definable for any data object in the system including interval, start time, and stop time.

1) Resolution: Interval periods shall be adjustable down to one minute.
2) Multiple Interval Period: Each trended point shall have the ability to be trended at a different trend interval.

c. Trend Data:

1) Sampled and stored on the building controller panel.

2) Auto-Delete Period: Software shall be capable of automatically deleting stored trend data after a user-adjustable period of time. Each trended point shall have the ability to have a different auto-delete interval period.
3) Archivable on hard disk or server.
4) Retrievable for use in reports, spreadsheets and standard database programs.
5) Protected and encrypted format to prevent manipulation or editing of historical data and event logs.

d. Trend Graph Display:

1) Group Trend Time Series Plots:

a) Provide user-selectable Y-axis points.
b) Provide user editable titles, point names, and Y-axis titles.
c) Individual trended points shall be able to be grouped into groups of up to four points per plot with up to four plots per page.

2) X-Y Trend Plots:

a) User selectable X and Y trend inputs.
b) User editable titles, point names, and X and Y-axis titles.
c) User selectable time period options:

i) 1-day 24-hour period.
ii) 1-week 7-day period.
iii) 1-month period with appropriate days for the month selected.
iv) 1-year period.
v) User shall be able to select the beginning and ending period for each X-Y chart, within the time domain of the database being used.
vi) User selectable display up to 6 plots per screen in 2 columns.

3) Automatic Scaling: System shall automatically scale the axis on which trends are displayed when multiple points with different trend interval periods are selected for graphical display.
4) Dynamic Update: Trends shall be able to dynamically update at operator-defined intervals.
5) Zoom: Software shall allow zoom-in function for detailed examination of trends.

e. Numeric Value Display: Software shall display value of any sample on a trend when picked.

9. Alarm and Event Log:

a. View all system alarms and change of states from any system location.
b. List events chronologically.
c. List alarm priority.
c. Allow operator with proper security to acknowledge and clear alarms. Log operator and time when alarm is acknowledged.
d. Archive alarms not cleared by operator to the workstation.

10. Object, Property Status, and Control:

a. Provide a method to view, edit if applicable, the status of any object and property in the system.
b. Status Available by the Following Methods:

1) Menu.
2) Graphics.
3) Custom Programs.

11. Clock Synchronization:

a. The real-time clocks in all building control panels and workstations shall be able to automatically synchronize daily from any operator-designated device in the system.
b. The system shall automatically adjust for daylight savings and standard time, if applicable.

12. Reports and Logs:

a. Reporting Package:

1) Allow operator to select, modify, or create reports.
2) Definable as to data content, format, interval, and date.
3) Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.
4) Provide ability to obtain real-time logs of all objects available by type or status such as alarm, lockout, normal, etc.
5) Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
6) Allow printing on operator command or specific time(s).

b. Standard Report Format Options:

1) Objects with current values.
2) Global modification values.
3) Current alarms not locked out.
4) Disabled and overridden objects, points and variables.
5) Objects in manual or automatic alarm lockout.
6) Objects in alarm lockout currently in alarm.
7) Objects currently in override status.
8) Objects in Schedules

a) Daily.
b) Weekly.
c) Holiday.

9) Logs:

a) Alarm History.
b) System messages.
c) System events.
d) Trends.

c. Custom Report Format Options:

1) Daily.
2) Weekly.

3) Monthly.
4) Annual.
5) Time and date stamped.
6) Title.
7) Facility name.
8) Point Groups.

a) User-selectable.
b) Group may be comprised of specific points, group of equipment objects, group of groups, or for the entire facility without restriction due to the hardware configuration of the BAS.

d. Electrical, Fuel, and Weather:

1) Electrical Meter(s):

a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.

2) Fuel Meter(s):

a) Monthly showing daily fuel consumption for each meter.
b) Annual summary showing monthly consumption for each meter.

3) Weather:

a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.

13. Global Modify:

a. Allow global modification of all editable data. Similar data shall be grouped into logical objects based on building function, mechanical system, building layout, or any other logical grouping of points.
b. Allow each common type of equipment to be excluded or included within the global editing process.
c. Display status information on all similar points in one global report.
d. Allow modification of the following:

1) Individual data point edited.
2) List of all points within the category.
3) Global change field.
4) Copy feature to assist in downloading the new changes.
5) Verification that all changes were completed.

e. Include a change-all feature to change all selections.
f. Prevent acceptance of changes until an accept icon is acknowledged.

G. Workstation Applications Editors:

1. Provide editing software for each system application at the PC workstation.
2. Edited applications shall be automatically downloaded and executed at the controller panel.
3. Programming Description: Definition of operator device characteristics, ASC's, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.

4. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hard copy printouts of all configuration and application data.
5. System definition and modification procedures shall not interfere with normal system operation and control.
6. Provide consistent text-based displays of all system point and system applications.
7. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.
8. Full screen editor for each application shall allow operator to view and change:

    a. Configuration.
    b. Name.
    c. Control parameters.
    d. Set-points.
    e. Schedules.

9. Scheduling:

    d. Allow scheduling down to the zone or room level.
    a. Monthly calendar indicates schedules, holidays, and exceptions.
    b. Allows several related objects to be grouped, scheduled, and copied to other objects or dates.
    c. Start and stop times adjustable from master schedule.
    e. Schedule expiration.
    d. Temporary overrides of systems with user adjustable time-out.
    f. Provide minimum three tiers of priorities for scheduling.

        1) Priority 1: Event, temporary, or override.
        2) Priority 2: Calendar.
        3) Priority 3: Default.

    g. Higher priority schedules shall overlay with lower priority schedules without interrupting or deleting them. Upon expiration of a higher priority schedule, schedule shall revert to next lower priority.
    h. Expired priority 1 and priority 2 schedules shall be automatically deleted after execution.

10. Custom Application Programming:

    a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
    b. Programming Features:

        1) English oriented programming language, allowing for free form programming.
        2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
        3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
        4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
        5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.

6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.
8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values can be used in IF/THEN comparisons, calculations, programming statement logic, etc.
9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

2.7 CONTROLLER SOFTWARE

A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.

B. System Security:

1. User access secured via user passwords and user names.
2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
3. User Log On/Log Off attempts are recorded.
4. Automatic Log Off occurs following the last keystroke after a user defined delay time.

C. Object or Object Group Scheduling:

1. Weekly Schedules Based on Separate, Daily Schedules:

a. Include start, stop, optimal stop, and night economizer.
b. 10 events maximum per schedule.
c. Start/stop times adjustable for each group object.

2. Exception Schedules:

a. Based on any day of the year.
b. Defined up to one year in advance.
c. Automatically discarded and replaced with standard schedule for that day of the week upon execution.

3. Holiday or Special Schedules:

a. Capability to define up to 99 schedules.
b. Repeated annually.
c. Length of each period is operator defined.

D. System Coordination: Provide a standard application for equipment coordination. The application shall provide the operator with a method of grouping together equipment based on function and location. Groups shall be capable of being used for scheduling and other applications.

E. Alarms:

1. Binary object is set to alarm based on the operator specified state.
2. Analog object to have high/low alarm limits.
3. All alarming is capable of being automatically or manually disabled.
4. Alarm Reporting:

    a. Operator determines action to be taken for alarm event.
    b. Alarms to be routed to appropriate workstation.

5. Reporting Action Options:

    a. Start Programs.
    b. Print.
    c. Logged.
    d. Custom messaging.
    e. Graphical displays.
    f. Dial out to workstation receivers via system protocol.

F. Demand Limiting:

1. Monitor building power consumption.
2. Demand limit controlled via load shedding or load restoration in a predetermined and predictive manner. Reference the control drawings and sequences of operation for additional information.
3. Demand Reduction Methods:

    a. Supply air temperature reset.
    b. Space temperature set-point reset.
    c. Equipment off/on prioritization.

4. Relevant variables that influence demand limiting control are based on the power company methodology for computing demand charges.
5. Provide demand limiting prediction and control for any individual meter monitored by the system or for the total of any combination of meters.
6. Operator On-Line Changes Allowed:

    a. Addition and deletion of loads controlled.
    b. Changes in demand intervals.
    c. Changes in demand limit for meter(s).
    d. Maximum equipment shutoff time.
    e. Minimum equipment shutoff time.
    f. Select rotational or sequential shedding and restoring.
    g. Shed/restore priority.

7. Information and Reports available Hourly, Daily, and Monthly:

    a. Total electric consumption.
    b. Peak demand.
    c. Date and time of peak demand.
    d. Daily peak demand.

G. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.

H. Sequencing: Application software based upon specified sequences of operation on the control drawings.

I. PID Control Characteristics:

1. Provide proportional-integral algorithms.
2. Direct or reverse action.
3. Anti-windup.
4. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
5. User selectable controlled variable, set-point, and PI gains.

J. Staggered Start Application:

1. Prevents all controlled equipment from simultaneously restarting after power outage.
2. Order of equipment startup is user selectable.

K. Anti-Short Cycling:

1. All binary output objects protected from short-cycling.
2. Allows minimum on-time and off-time to be selected.
3. Allows the number of times each piece of equipment may be cycled within any one-hour period.

L. On-Off Control with Differential:

1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.

M. Trending: Building controllers shall allow collection and delivery of (time, value) pairs.

N. Totalization:

1. Run-Time Totalization:

a. Totalize run-times for all binary input objects.
b. Provides operator with capability to assign high run-time alarm.
c. Generates unique, user-specified messages when the limit is reached.
d. Resolution: Adjustable down to one minute.

2. Pulse Totalization:

a. Totalize consumption for user-selected analog and binary pulse input-type objects.
b. Configurable for a daily, weekly, or monthly basis.
c. Provide calculation and storage accumulations of up to 9,999,999 units (e.g. KWH, gallons, KBTU, tons, etc.).
d. Resolution: Adjustable down to one minute.
e. Warning Limit: User definable. Generate unique, user-specified messages when the limit is reached.
f. The information available from the Pulse Totalization shall include, but not be limited to, the following:

1) Peak Demand, with date and time stamp
2) 24-hour Demand Log
3) Accumulated KWH for day
4) Sunday through Saturday KWH usage
5) Sunday through Saturday Demand kW
6) Demand kW annual history for past 12 periods
7) KWH annual history for past 12 periods

3. Event Totalization:

    a. Count user-selected events, such as the number of times a pump or fan system is cycled on and off.
    b. Provide storage accumulations of up to 9,999,999 events before reset.
    c. Warning Limit: User definable. Generate unique, user-specified messages when the limit is reached.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices and wiring are installed prior to installation proceeding.

E. Verify the integrity of control wiring, raceways, control panels, sensors, and control devices prior to reusing for the new work.

F. Verify wiring insulation is defect free and test wiring for continuity and ground faults.

3.2 INSTALLATION

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

B. Coordination:

1. The BAS Contractor shall execute their work in such a manner as to cause the minimum interference to the operation of the building.
2. Cooperate with other contractors performing work on this project as necessary to achieve a complete and coordinated installation. Each Contractor shall consult the Drawings and Specifications for all trades to determine the nature and extent of others work.
3. Where the BAS shall share a common network backbone via a VLAN, provide temporary network access for BAS construction, startup, and commissioning. Coordinate transition of network operation to Owner's IT group.
4. Coordinate with the Owner to display additional virtual points on individual schematic graphic screens that are not directly associated with that system. Examples may include outdoor air temperature or global alarm conditions.

B. Web Services Enabled Network:

5. Provide an IP network data drop for connection of BAS into Owner's IP network. Coordinate final location of IP network data drop with the Owners' IT staff.
6. If the Owner has no preference or not indicated on the drawings, locate data drop within the main BAS control panel.

7. Coordinate with the Owner's IT department to implement proper security measures, including secure access to the network data drop and firewalls at all virtual access points to the internet to protect access to the BAS.

C. General Workmanship:

1. Install equipment, piping, and wiring/raceway parallel to building lines wherever possible.
2. Install all equipment in readily accessible locations.
3. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
4. All installations shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
8. Control wiring routed in wall cavities shall be installed in conduit.
9. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
10. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.

C. Controllers:

1. Install controllers in a locked control panel. Provide common keying for all controller covers.
2. Provide a separate controller for each piece of controlled equipment, such as an AHU, FCU, VAV box, etc. A controller may control more than one piece of equipment provided that all points associated with the equipment are assigned to the same BAS controller. Global points used for control loop reset are exempt from this requirement.
3. Select building controllers and custom application controllers to provide the required I/O point capacity required to monitor all of the hardware points listed on the control drawings.
4. Application specific controllers may be used where factory programming is capable of executing all control functions specified in the sequences of operation. Contractor shall add supplemental controllers, devices, and programming as required to execute the specified control function if the ASC cannot.

D. Wiring:

1. All control and interlock wiring shall comply with national and local electrical codes.
5. Properly ground all controllers.
6. Wire all safety devices through both hand and auto positions of motor starting device to ensure 100 percent safety shut-off.
2. Provide interlock wiring between devices as indicated on the control drawings.
3. Provide electrical wiring for relays (including power feed) for temperature and pressure indication.
4. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.
5. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.
7. Conceal all low voltage wiring in finished rooms.
8. Conceal all low voltage wiring in unfinished rooms below the elevation of the lights. Low voltage wiring above the elevation of the lights may be exposed.
9. Routing of low voltage wiring above working heights in equipment rooms and above accessible ceilings is acceptable subject to following criteria:

    a. Wiring shall be plenum rated.
    b. Do not lay wiring on ceiling tiles.

6. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended applications.
7. All wiring in mechanical, electrical, service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 10 feet.
8. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two wires (e.g., relays and transformers).
9. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it and neatly tied at 10 foot intervals.
10. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
11. All wire-to-device and wire-to-wire connections shall be made at a terminal block or terminal strip.
12. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
13. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, coordinate with Division 26 to provide step-down transformers.
14. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
15. Install plenum wiring in sleeves where it passes through floors and walls. Maintain fire rating at all penetrations.
16. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
17. Include one pull string in each raceway 1 inch and larger.
18. Use coded conductors throughout with conductors of different colors.
19. Control and status relays shall be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
20. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (e.g., steam pipes or flues).
21. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
22. Install insulated bushing on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
23. Terminate all control and/or interlock wiring and maintain updated (as-built) wiring diagrams with terminations identified at the job site.
24. Terminate BAS sensor input wiring cable shield by taping back at the field device and connect shield to the grounded control panel chassis or sub-panel.
25. Terminate BAS comm bus cable shield between controllers per manufacturer recommendations.
26. Terminate management level/enterprise level network wiring cable shield by wrapping the drain wire around the foil shield and connecting the ground strip to the drain wire.
27. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than 1/2 inch electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
28. Raceway shall be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations shall be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

E. Communication Wiring:

1. Adhere to the items listed in the "Wiring" article in Part 3 of this specification in addition to the requirements listed below.
2. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication wiring.
3. Do not exceed 328 feet in Ethernet wiring length between switches or repeaters.
4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
5. Do not install power wiring, in excess of 30 Vac RMS, in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, use separate twisted shielded pairs with the shields grounded in accordance with the manufacturer's wiring practice.
6. Communication conduits shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.
7. Do not exceed maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer during installation.
8. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
9. When a cable enters or exits a building, install a lightning arrestor between the lines and ground. Install the lightning arrestor according to the manufacturer's instructions.
10. Ground (earth ground) all shields at one point only, to eliminate ground loops.
11. All runs of communications wiring shall be unspliced length when that length is commercially available.
12. Terminate shielded cable splices in accessible locations. Harness cables with cable ties.
13. Make all wire-to-device and wire-to-wire connections at a terminal block or terminal strip.
14. Label all communications wiring to indicate origination and destination data.
15. Ground coaxial cable in accordance with NEC regulations.
16. Install BACnet MS/TP communications wiring in accordance with ASHRAE/ANSI Standard 135

    a. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 17 pF per foot at 76,800 Baud.
    b. The maximum length of an MS/TP segment shall be 3000 ft with AWG 22 or 24 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
    c. The maximum number of nodes per segment shall be 50. Additional nodes may be accommodated by the use of repeaters.
    d. An MS/TP EIA-485 network shall have no T connections.

F. Identification of Hardware and Wiring:

1. Label all wiring and cabling, including that within factory-fabricated panels, at each end within 2 inch of termination with the BAS address or termination number.
2. Permanently label or code each point of field terminal strips to show the instrument or item served.
3. Identify control panels with minimum 1/2 inch letters on laminated plastic nameplates.
4. Identify all other control components with permanent labels. Label all plug-in components such that removal of the component does not remove the label.
5. Identify room sensors related to terminal box or valves with nameplates.
6. Maintain manufacturers' nameplates and UL or CSA labels visible and legible after equipment is installed.
7. Identifiers shall match record documents.

3.3 STARTUP AND DEMONSTRATION

A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing the BAS in permanent operation.

B. Contractor shall provide an on-site controls technician or programmer familiar with the project BAS installation and system programming to assist the Commissioning Agent as directed during all phases of system functional testing.

C. Coordinate with Owner the setup of logins, passwords, and security level access for individuals requiring access to the BAS.

D. BAS graphics shall be updated with final equipment names, equipment numbers, room names and room numbers to match the final construction documents and any Owner changes made prior to occupancy.

D. BAS shall be set up and checked by factory trained technicians skilled in the setting and adjustment of the BAS equipment used in this project. Technicians shall be experienced in the type of HVAC systems associated with this project.

E. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

F. Test each control device to ensure that it is operating properly and is calibrated to the appropriate operating requirements. Run each control device through its range of operation and sequence. Verify all normal positions are correct. Adjust and tune PID control constants to achieve proper system operation.

1. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
2. Demand limiting. The Contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
3. Optimum start/stop. The Contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
4. Any tests that fail to demonstrate the operation of the BAS shall be repeated at a later date. The Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

G. Test and verify control interfaces to other building systems integrated into the network.

H. Verify all alarms and interlocks.

1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
4. Verify fire/smoke and smoke damper functionality. Verify that they respond to the proper fire alarm system general, zone, and/or detector trips.

I. Document on system equipment schedules the final setting of controller PID constant settings, setpoints, manual reset values, maximum and minimum controller output, and ratio and bias settings in units and terminology specific to the controller. Store documentation with operator workstation.

J. Demonstrate complete and operating system to Owner.

1. Prior to acceptance, the BAS shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, start-up, and debugging process.
3. The Contractor shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. Any test equipment required to provide the proper operation shall be provided by and operated by the Contractor.
4. Demonstrate compliance with sequences of operation through all modes of operation.
5. Demonstrate complete operation of operator interface.

K. Acceptance:

1. All tests described in this specification shall have been performed to the satisfaction of the Owner prior to the acceptance of the BAS as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the completion requirements if stated as such in writing by the Contractor and submitted for approval by the Owner. Such tests shall then be performed as part of the warranty.
2. The BAS shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved.

3.4 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for one year from Date of Substantial Completion.

3.5 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of eight hours on the operation and maintenance of the equipment provided under this section.

B. Organize the training into sessions or modules for different levels of operators. Owner designated personnel shall be trained based on the level of operator training described below.

C. Day-to-day Operator Training:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Proficiently operate the BAS.
3. Understand BAS architecture and configuration.
4. Understand BAS components.
5. Understand system operation, including BAS control and optimizing routines (algorithms).

6. Operate the workstation and peripherals.
7. Log on and off the system.
8. Access graphics, point reports, and logs.
9. Adjust and change system set points, time schedules, and holiday schedules.
10. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
11. Understand BAS drawings and Operation and Maintenance manual.
12. Understand the job layout and location of control components.
13. Access data from BAS controllers and ASCs.
14. Operate portable operator's terminals.
15. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.

D. Advanced Operator Training:

1. Make and change graphics on the workstation.
2. Create, delete, and modify alarms, including annunciation and routing of these.
3. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals.
4. Create, delete, and modify reports.
5. Add, remove, and modify system's physical points.
6. Create, modify, and delete programming.
7. Add panels when required.
8. Add operator interface stations.
9. Create, delete, and modify system displays, both graphical and others.
10. Perform BAS field checkout procedures.
11. Perform BAS controller unit operation and maintenance procedures.
12. Perform workstation and peripheral operation and maintenance procedures.
13. Perform BAS diagnostic procedures.
14. Configure hardware including PC boards, switches, communication, and I/O points.
15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
16. Adjust, calibrate, and replace system components.

E. System Manager/Administrator Training:

1. Maintain software and prepare backups.
2. Interface with job-specific, third-party operator software.
3. Add new users and understand password security procedures.

F. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

G. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

H. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping.

B. Refrigerant.

C. Moisture and liquid indicators.

D. Valves.

E. Strainers.

F. Check Valves.

G. Pressure regulators.

H. Pressure relief valves.

I. Filter-driers.

J. Solenoid valves.

K. Expansion valves.

1.2 SUBMITTALS

A. Product Data: Provide general assembly of valves and specialties, including manufacturer's catalog information. Provide manufacturer's catalog data including load capacity.

B. Shop Drawings showing layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and proximate to equipment.

C. Test reports specified in Part 3 below.

D. Manufacturer's Installation Instructions: Indicate support requirements, connection requirements and isolation requirements for servicing.

E. Brazer's Certificates signed by Contractor certifying that brazers comply with requirements specified under "Quality Assurance" below.

F. Maintenance Data: Include maintenance instructions for refrigerant valves and piping specialties, for inclusion in Operation and Maintenance manual.

1.3 QUALITY ASSURANCE

A. Comply with Division 23 Section, "Basic Piping Materials and Methods."

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of documented experience.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver and store piping and specialties in shipping containers with labeling in place.

B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, and maintain sealed until connected into system.

PART 2 - PRODUCTS AND MATERIALS

2.1 REGULATORY REQUIREMENTS

A. Comply with ASME/ANSI B31.5: ASME Code for Pressure Piping - Refrigerant Piping.

B. Comply with ANSI/ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.

C. Comply with applicable Mechanical Code.

D. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

2.2 PIPING

A. Copper Tubing:

1. ASTM B280, Type ACR, seamless, hard-drawn straight lengths and soft-annealed coils. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.
2. ASTM B88, Type L, seamless, hard-drawn straight lengths and soft-annealed coils.
3. ASTM B88, Type K, seamless, hard-drawn straight lengths and soft-annealed coils.

B. Refrigerant Line Kits:

1. Type ACR seamless copper roll of refrigerant tubing with pipe diameters as recommended by the manufacturer and of length as required for the installation.
2. Factory or field installed flexible unicellular insulation:

    a. Minimum thickness as required per Division 23 section "HVAC Insulation".

3. Quick-connect flare tubing compression fittings or solder connections as required to match the connections of the condensing unit and evaporator coil.

2.3 FITTINGS

A. Wrought-Copper Fittings for Solder-joint: ANSI B16.22, streamlined pattern.

B. Mechanical Flared Fittings: ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tube.

C. Press Fit Fittings:

1. Acceptable Manufacturers:

   a. Conex Banninger-Maxipro ACR
   b. Parker-ZoomLock
   c. Rapid Locking System

2. Fittings shall be approved with copper tubing conforming to ASTM B280, B88 or B743.
3. Fittings shall be approved with hard (drawn) and soft (annealed) copper tubing Type ACR, L and K.
4. Fittings shall be rated for continuous operating temperature from -40 F to 250 F and maximum operating pressure of 700 psi.
5. Fittings shall be compatible with the oils and lubricants used in the refrigerant.

2.4 JOINING MATERIALS

A. Refer to Division 23 Section "Basic Piping Materials and Methods" for joining materials.

2.5 PIPE SUPPORTS

A. Hanger, supports, and anchors are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing. Provide plastic galvanic isolators for copper tubing where indicated.

2.6 REFRIGERANT

A. Refrigerant:. R- 410A, as defined in ASHRAE Standard 34.

2.7 MOISTURE AND LIQUID INDICATORS

A. Manufacturers

1. Emerson Electric.
2. Henry Technologies.
3. Parker Hannifin/Refrigeration and air Conditioning.
4. Sporlan, Division of Parker Hannifin.

B. Moisture/liquid Indicators: Single port type, UL listed, with forged brass body, solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; rated for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

2.8 VALVES

A. Manufacturers:

1. Danfoss.
2. Emerson Electric.
3. Henry Technologies.
4. Parker Hannifin/Refrigeration and air Conditioning.
5. Sporlan, Division of Parker Hannifin.

B. General: Complete valve assembly shall be UL-listed and designed to conform to AHRI 760. Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

C. Diaphragm Packless Valves: Globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F

D. Ball: Two piece bolted forged brass body with Teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seal; maximum working pressure 500 psig and maximum temperature of 275 F.

E. Globe: Cast bronze body, with cast bronze or forged brass wing cap and bolted bonnet; replaceable resilient seat disc; plated steel stem. Valve shall be capable of being repacked under pressure. Valve shall be straight through or angle pattern, with solder-end connections; for maximum working pressure of 500 psig and maximum operating temperature of 275 deg. F.

2.9 STRAINERS

A. Manufacturers:

1. Danfoss.
2. Parker Hannifin/Refrigeration and air Conditioning.
3. Sporlan, Division of Parker Hannifin.

B. Strainers: 500 psig maximum working pressure; forged brass body with Monel 80-mesh screen, and screwed cleanout plug; Y-pattern, with solder end connections.

2.10 CHECK VALVES

A. Manufacturers:

1. Danfoss.
2. Parker Hannifin/Refrigeration and air Conditioning.
3. Sporlan, Division of Parker Hannifin.

B. Check Valves - Smaller Than 7/8 inch: 500 psig maximum operating pressure, 300 deg. F maximum operating temperature; cast bronze or forged brass body, with removable piston, Teflon

seat, and stainless steel spring; straight through globe design. Valve shall be straight through pattern, with solder-end connections.

C. Check Valves - 7/8 inch and Larger: 450 psig maximum operating pressure, 300 deg. F maximum operating temperature; cast bronze body, with cast bronze or forged brass bolted bonnet; floating piston with mechanically retained Teflon seat disc. Valve shall be straight through or angle pattern, with solder-end connections.

2.11 PRESSURE REGULATORS

A. Manufacturers:

1. Danfoss.
2. Emerson Electric.
3. Parker Hannifin/Refrigeration and air Conditioning.
4. Sporlan, Division of Parker Hannifin.

B. Evaporator Pressure Regulating Valves: Pilot-operated, forged brass or cast bronze; complete with pilot operator, stainless steel bottom spring, pressure gage tappings, 24 volts DC, 50/60 Hz, standard coil; and wrought copper fittings for solder end connections.

2.12 PRESSURE RELIEF VALVES

A. Manufacturers:

1. Danfoss.
2. Parker Hannifin/Refrigeration and air Conditioning.
3. Sporlan, Division of Parker Hannifin.

B. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB, selected to ASHRAE Std 15, with standard setting of 235 psi.

2.13 FILTER DRIERS

A. Manufacturers:

1. Danfoss.
2. Emerson Electric
3. Parker Hannifin/Refrigeration and air Conditioning.
4. Sporlan, Division of Parker Hannifin.

B. Filter-driers: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel cap screws, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter-drier core kit, including gaskets, as follows:

1. Standard capacity desiccant sieves to provide micronic filtration.

C. Suction Line Filter-Drier: 350 psig maximum operation pressure, 225 deg. F maximum operating temperature; steel shell, and wrought copper fittings for solder end connections. Permanent filter element shall be molded felt core surrounded by a desiccant for removal of acids and moisture for refrigerant vapor.

D. Suction Line Filters: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel cap screws, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter core kit, including gaskets.

2.14 SOLENOID VALVES

A. Manufacturers:

1. Danfoss.
2. Emerson Electric.
3. Parker Hannifin/Refrigeration and air Conditioning.
4. Sporlan, Division of Parker Hannifin.

B. Valves: 250 deg. F temperature rating, 500 psig working pressure; forged brass body, with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve.

C. Furnish complete with NEMA 1 solenoid enclosure with 1/2 inch conduit adapter, and 24 volt, 60 Hz. normally closed holding coil.

2.15 EXPANSION VALVES

A. Manufacturers:

1. Danfoss.
2. Emerson Electric.
3. Parker Hannifin/Refrigeration and air Conditioning.
4. Sporlan, Division of Parker Hannifin.

B. Thermal Expansion Valves: thermostatic adjustable, modulating type; size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Valves shall have copper fittings for solder end connections; complete with sensing bulb, and an external equalizer line.

C. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select valve to avoid being undersized at full load and excessively oversized at part load.

PART 3 - EXECUTION

3.1 PIPE APPLICATION SCHEDULE

A. Above Grade:

1. Type L or Type ACR tubing.

B. If other than Type ACR tubing is used, clean and protect inside of tubing as specified in Article "CLEANING" below.

C. At contractor's option, use refrigerant line kits for refrigerant systems of 5 tons and smaller capacity.

3.2 INSTALLATION, GENERAL

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

B. Install piping to ASME B31.9 requirements.

C. Reference Division 23 Section "Basic Piping Materials and Methods" for general piping installation requirements.

D. Do not install PVC or non-plenum rated HDPE piping in return air plenums.

3.3 PIPING INSTALLATIONS

A. General: Install refrigerant piping in accordance with ASHRAE Standard 15 - "The Safety Code for Mechanical Refrigeration" and the equipment manufacturer's installation requirements.

B. Install piping in as short and direct arrangement as possible to minimize pressure drop.

C. Install piping for minimum number of joints using as few elbows and other fittings as possible.

D. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

E. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

F. Insulate piping per Division 23 Section "HVAC Insulation."

1. Do not install insulation until system testing has been completed and all leaks have been eliminated.

G. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

H. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

I. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with 1/2 inch per 10 feet downward slope away from the compressor.
2. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
3. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.
4. Liquid lines may be installed level.

J. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

K. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

3.4 HANGERS AND SUPPORTS

A. Comply with the requirements of Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Provide insulation saddles and protection shields as specified in Section "Hangers & Supports for HVAC Piping & Equipment". Provide insulation inserts as specified in Section "HVAC Insulation".

C. Install hangers with the following minimum rod sizes and maximum spacing:

NOM. PIPE SIZE	MAX. SPAN-FT	MIN. ROD SIZE – INCHES
Up to 3/4	5	3/8
1	6	3/8
1-1/4	7	3/8
1-1/2	8	3/8

D. Support vertical runs at each floor. Support riser piping independently of connected horizontal piping.

E. Install a support within one foot of each change of direction.

F. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

3.5 PIPE JOINT CONSTRUCTION

A. Reference Division 23 Section, "Basic Piping Materials and Methods" for basic pipe joint construction.

B. Press-Fit Joints: Installers of the press-fit joints shall be trained using manufacturers training tools prior to installing any press-fit joints.

1. Prepare the copper tube in accordance with manufacturers instructions.
2. Install fittings to minimum depth required by the fitting manufacturer.
3. Crimp the fitting only using the crimping tools allowed by the manufacturer using the jaw size appropriate for the tube diameter.
4. Verify the joint is properly installed using crimp gauges or manufacturer's approved verification methods.

3.6 VALVE AND PIPING SPECIALTIES INSTALLATIONS

A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions.

B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.

C. Install a full sized, 3-valve bypass around each drier.

D. Install solenoid valves ahead of each expansion valve . Install solenoid valves in horizontal lines with coil at the top.

1. Electrical wiring for solenoid valves is specified in Division 26. Coordinate electrical requirements and connections.

E. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

1. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.
2. Install the valve in such a location so that the diaphragm case is warmer than the bulb.
3. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount bulb in a trap or at the bottom of the line.
4. Where external equalizer lines are required make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

F. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

G. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

H. 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.

1. Install moisture/liquid indicators in lines larger than 2-1/8 inch OD, using a bypass line.

3.7 EQUIPMENT CONNECTIONS

A. The Drawings indicate the general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow servicing and maintenance.

3.8 FIELD QUALITY CONTROL

A. Inspect, test, and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI. Provide test report summarizing the test procedures and results of the tests.

B. Repair leaking joints using new materials, and retest for leaks.

C. Field Test: Every refrigerant-containing part of every system that is erected on the premises, except safety devices, pressure gauges, control mechanisms, compressors, evaporators, and systems that are factory-tested, shall be tested and proved tight after complete installation and before operation. The high side and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high side and low side of the system, respectively.

D. Testing Procedure: Tests shall be performed with dry nitrogen. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system's components.

3.9 CLEANING

A. Before installation of copper tubing other than Type ACR tubing, clean the tubing and fitting using following cleaning procedure:

1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.
2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
3. 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.
4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.10 ADJUSTING AND CLEANING

A. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Clean and inspect refrigerant piping systems in accordance with requirements of Division 23 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

C. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.11 STARTUP

A. Charge system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.
2. Evacuate refrigerant system with vacuum pump; until temperature of 35 deg F is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
5. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.
6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Train Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.

C. Review data in Operating and Maintenance Manuals. Refer to Division 01 section "Closeout Procedures."

D. Schedule training with Owner through the Architect, with at least 7 days advance notice.

END OF SECTION

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:

1. Metal ductwork.
2. Underground metal ductwork.
3. Duct liner.
4. Duct sealants.
5. Duct hangers and supports.
6. Wire rope hanging system.
7. Manufactured ductwork and fittings.
8. Snap-Lock duct system.
9. Modular ductwork and fittings.

1.2 REFERENCE STANDARDS

A. - ASHRAE Handbook - Fundamentals.

B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.

C. ASTM A90 - Standard Specification for Weight [Mass] of Coating on Iron and Steel Articles with Zinc of Zinc-Alloy Coatings.

D. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

E. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

F. ASTM A700 - Standard Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment.

G. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.

H. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

I. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

J. ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

K. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

L. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

M. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

N. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

O. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.

P. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems, 2013

Q. AWS D1.1 - Structural Welding Code - Steel

R. AWS D9.1 - Sheet Metal Welding Code

S. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements.

T. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.

U. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

V. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

W. NADCA ACR-2002 - Assessment, Cleaning & Restoration of HVAC Systems; National Air Duct Cleaners Association

X. NAIMA - Duct Cleaning Guide; North American Insulation Manufacturers Association

Y. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

Z. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

AA. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

BB. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

CC. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines.

DD. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.

EE. TIMA AHC-101; Thermal Insulation Manufacturers Association

FF. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.

GG. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

HH. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies; Current Edition, Including All Revisions.

1.3 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:

1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
2. Joints: Joints include girth joints; branch and subbranch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.4 SYSTEM PERFORMANCE REQUIREMENTS

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

1.5 SUBMITTALS

A. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:

1. Duct Liner.
2. Sealing Materials.
3. Fire-Stopping Materials.
4. Duct Cleaning Products.

B. Shop drawings from duct fabrication shop, drawn to a scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as the Contract Drawings, detailing:

1. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.
2. Duct layout, indicating pressure classifications, duct gauge and sizes in plan view. For exhaust ducts systems, indicate the classification of the materials handled as defined in this Section.
3. Fittings.
4. Reinforcing details and spacing.
5. Seam and joint construction details.
6. Penetrations through fire-rated and other partitions.
7. Terminal heating and cooling unit, coil, humidifier and duct silencer installations.
8. Locations of fire and fire/smoke dampers and associated duct access doors.
9. Locations of cleanout and access doors in grease exhaust ducts.
10. Location of manual balancing dampers.
11. Duct smoke detector locations. Refer to electrical drawings for general locations and coordinate locations with the electrical contractor.
12. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

C. Coordination drawings for ductwork installation in accordance with Division 23 Section "General Mechanical Requirements." In addition to the requirements specified in "General Mechanical Requirements" show the following:

1. Coordination with ceiling suspension members.
2. Spatial coordination with other systems installed in the same space with the duct systems.
3. Coordination of ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.
4. Coordination with ceiling-mounted lighting fixtures and air outlets and inlets.

D. Record drawings including duct systems routing, fittings details, reinforcing, support, and installed accessories and devices, in accordance with Division 23 Section "General Mechanical Requirements" and Division 1.

E. Welding certificates including welding procedures specifications, welding procedures qualifications test records, and welders' qualifications test records complying with requirements specified in "Quality Assurance" below.

1.6 QUALITY ASSURANCE

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

B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of documented experience.

C. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel" for hangers and supports and AWS D9.1 "Sheet Metal Welding Code."

D. Qualify each welder in accordance with AWS qualification tests for welding processes involved. Certify that their qualification is current.

E. NFPA Compliance: Comply with the following NFPA Standards:

1. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems," except as indicated otherwise.
2. NFPA 90B, "Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
3. NFPA 96, "Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors for Commercial Cooking Equipment," Chapter 3, "Duct System," for kitchen hood duct systems, except as indicated otherwise.

F. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Provide ductwork systems in conformance with "HVAC Duct Construction Standards – Metal and Flexible," latest edition.

G. Underwriter's Laboratories (UL): Comply with the UL standards listed within this section. Provide mastic and tapes that are listed and labeled in accordance with UL 181A and marked according to type.

H. National Air Duct Cleaners Association, Inc. (NADCA): Clean ductwork systems in accordance with the standard Assessment, Cleaning and Restoration of HVAC Systems (ACR 2002).

1.7 PROTECTION AND REPLACEMENT

A. Protect ductwork during shipping and storage from dirt, debris and moisture damage. Provide plastic covers over ends of ductwork during shipping, storage and installation.

B. Replace duct liner that is damaged and cannot be repaired satisfactorily, including insulation with vapor barrier damage and insulation that has been exposed to moisture during shipping, storage, or installation. Drying the insulation is not acceptable. Dry surfaces prior to installing new duct liner.

1.8 FIELD CONDITIONS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 - PRODUCTS AND MATERIALS

2.1 DUCT ASSEMBLIES

A. Ducts: Galvanized steel, unless otherwise indicated. Provide sheet metal in thickness indicated (minimum 26 gauge), packaged and marked as specified in ASTM A700.

B. Supply Air Ducts (constant volume or single zone VAV systems): 3 inches w.g pressure class, galvanized steel.

C. Return and Relief: 2 inch w.g. pressure class, galvanized steel.

D. General Exhaust: 2 inch w.g. pressure class, galvanized steel.

E. Outside Air Intake: 2 inch w.g. pressure class, galvanized steel.

F. Transfer Air and Sound Boots: 1/2 inch wg pressure class, galvanized steel.

G. Exterior Ductwork: Ductwork installed exterior to the building shall be minimum #18 gauge with longitudinal and transverse joints welded or sealed airtight as specified under Paragraph "Seam and Joint Sealing".

H. Duct Liner Application: Provide duct liner on the following interior air ducts and where specified on the drawings.

1. Supply Ductwork:

a. As indicated on the plans for sound attenuation.
b. Exposed rectangular ductwork.
c. Exposed round ductwork.
d. First 15 feet of ductwork downstream of equipment outlets.

2. Return Ductwork.

    a. All ductwork within 10 feet of air handling equipment.
    b. Return and transfer air boots.
    c. Exposed rectangular ductwork.
    d. Exposed round ductwork.
    e. First 15 feet of ductwork upstream of equipment outlets.

3. Outside Air Ductwork

    a. Exposed outside air ductwork where indicated on plans.

2.2 MATERIALS

A. Sheet Metal, General: Provide sheet metal in thickness indicated (minimum 26 gauge), packaged and marked as specified in ASTM A 700.

B. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, lock-forming quality with G90/Z275 coating.. Provide mill phosphatized or galvanized finish for surfaces of ducts exposed to view that is to be field painted. Provide bright galvanized finish for ductwork that is exposed to view and not field painted.

C. Carbon Steel for Ducts: ASTM A1008/A1008M, Designation CS (commercial steel), cold-rolled, with oiled, exposed matte finish.

D. Aluminum for Ducts: ASTM B209 (ASTM B209M); aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength, with standard, one-side bright finish where ducts are exposed to view, and mill finish for concealed ducts.

E. Stainless Steel for Ducts: ASTM A 480, Type 316, with No. 4 finish on exposed surface for ducts exposed to view; Type 304, sheet form, with No. 1 finish for concealed ducts.

F. PVC-Coated Galvanized Steel: UL-181 Class 1 Listing. Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, lock-forming quality with G90/Z275 coating. Provide with factory-applied, 4-mil, PVC coating on exterior of ducts and fittings for underground applications, and the interior of ducts and fittings for fume-handing applications and 2-mil PVC coating on the reverse side of the ducts and fittings.

G. Duct Liner

1. General:

    a. Comply with NFPA Standard 90A and North American Insulation Manufacturers Association (NAIMA) Standard AHC-101.
    b. Liner shall have a flame spread rating of not more than 25 without evidence of continued progressive combustion and a smoke developed rating of no higher than 50, when tested in accordance with ASTM E84 or UL 723.
    c. Duct sizes on mechanical plans indicate clear inside airflow dimensions. Sheet metal sizes for ductwork with duct liner shall be increased accordingly to account for liner thickness.

2. Fiberglass: ASTM C1071, Type I or II, glass fibers firmly bonded together with a thermosetting resin with surface exposed to airstream coated to prevent erosion of glass fibers. Liner surface shall serve as a barrier against infiltration of dust and dirt, shall meet

ASTM C 1338 for fungi resistance and shall be cleanable using duct cleaning methods and equipment outlined by NAIMA Duct Cleaning Guide. Duct liner shall be rated for air velocity of 6,000 fpm.

a. Rectangular fiberglass duct liner shall be Owens Corning QuietR HD or approved equal for 1" thickness. Rectangular 1-1/2" thickness fiberglass duct liner shall be Certainteed ToughGard T, JohnsManville Linacoustic RC, Knauf Atmosphere, Owens Corning QuietR or approved equal.

    1) Thickness and Density:

        a) 1 inch, 3 pounds per cubic foot. (Conditioned Spaces)
        b) 1-1/2 inch, 1-1/2 pounds per cubic foot. (Unconditioned Plenums)

b. Round fiberglass duct liner shall be Certainteed ToughGard UltraRound, JohnsManville Spiracoustic Plus, Owens Corning QuietZone Spiral, or approved equal.

    1) Thickness and Density:

        a) 1 inch, 4 pound per cubic foot. (Conditioned Spaces)
        b) 1-1/2 inch, 4 pound per cubic foot. (Unconditioned Plenums)

c. Thermal Performance: Meet minimum "K-Factor" equal to 0.28 (Btu·in/h·sq ft·F) or better, at a mean temperature of 75°F and rated in installed condition in accordance with ASTM C518 and/or ASTM C177.

d. Noise Reduction Coefficient (NRC): Meet the following minimum NRC in accordance with ASTM C423 Type A Mounting:

    1) 1 Inch Thick: NRC 0.65.
    2) 1-1/2 Inch Thick: NRC 0.80.
    3) 2 Inch Thick: NRC 0.85.

e. Liner Adhesive: Comply with NFPA Standard 90A /UL 181 classified with flame spread/smoke development less than 25/50 and ASTM C 916. Adhesive shall be a minimum 50% solid content, water-based, non-oxidizing and have a service temperature of –20 to 200 F. Water-based adhesive shall be one of the following:

    1) Armacell LLC Armaflex 520 BLV low VOC.
    2) Design Polymerics DP 2502.
    3) Duro Dyne WIT.
    4) Foster 85-60.
    5) Childers CP-127.
    6) Johns Manville SuperSeal HV.
    7) Hardcast 951.
    8) United McGill Uni-Tack.

f. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.

    1) Fastener Pin Length: As required for thickness of insulation, and without projecting more than 1/8 inch into the airstream.
    2) Adhesive For Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.

3. Flexible Elastomeric Duct Liner: Insulation material shall be a flexible, closed cell, elastomeric insulation in sheet form that complies with ASTM C534. Material shall have a

maximum thermal conductivity of 0.27 Btu-in/h-sf-F and a minimum water vapor transmission of 0.08 perm-inches. Liner shall be 1 inch thick or greater to meet local code requirements.

a. Manufacturers:

1) Aeroflex USA, Inc Aerocel Sheet.
2) Armacell LLC, AP Armaflex SA or Amaflex Ultra.
3) K-Flex USA Liner Gray.

4. Flexible Elastomeric Round or Spiral Duct Liner: Compliance with ASTM C 534 Grade 1, Type II or ASTM C 1534, NFPA 90A or NFPA 90 B, Thickness: 1 inch, Thermal Conductivity: 0.28 Btu-in/hr sq ft F at 75 F mean temp, ASTM C 518 Noise Reduction Coefficient: 0.4, ASTM C 423 Sound Transmission Class (STC) 31, ASTM E90, EPA registered anti-microbial additive to inhibit mold and mildew, ASTM G21.

a. Manufacturers:

1) Armacell LLC, AP Spiraflex.
2) Approved equal.

H. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.

1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
2. Surface Burning Characteristics: Sealants shall be ASTM E84 or UL 723 listed with a flame spread index not more than 25 and a smoke-developed index not more than 50.
3. For Use with Flexible Ducts: UL labeled.
4. The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics. Duct tape shall not be used as a sealant on any ducts.
5. Joint and Seam Tape: 2 inches wide, glass-fiber-reinforced fabric.
6. Tape Sealing System: Woven-fiber tape impregnated with a gypsum mineral compound and a modified acrylic/silicone activator to react exothermically with the tape to form a hard, durable, airtight seal.
7. Solvent-Based Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant complying with FS TT-S-001657, Type I; formulated with a minimum of 70 percent solids. Approved products: Childers CP-140, Duro Dyne SGD, Fosters 32-14, or approved equal.
8. Water-Based Joint and Seam Sealant: Non-Fibrated: UL 181 listed. Sealant shall be rated to ±15 inches w.g. Sealant shall have a service temperature of –25 to 200 F and be freeze/thaw stable through 5 cycles. Approved products: Childers CP-146, Design Polymerics DP 1010, Ductmate Proseal/Fiberseal, Duro Dyne Duroseal, Fosters 32-1, United Duct Sealer (Water Based), and Hardcast 601.
9. Flanged Joint Mastics: One-part, acid-curing, silicone elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
10. Flanged Gasket Tapes: Butyl gasket shall be UL 181 classified. Gasket size shall be minimum 5/8 inch x 3/16 inch and have nominal 100 percent solid content. It shall be non-oxidizing, non-skinning and have a service temperature of –25 to 180 F. Approved Products: Design Polymerics DP 1040, Ductmate 440, and Hardcast 1104.

I. Fire Stopping

1. Fire-Resistant Sealant: Two-part, foamed-in-place, fire-stopping silicone sealant formulated for use in a through-penetration fire-stop system for filling openings around duct

penetrations through walls and floors, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.

2. Fire-Resistant Sealant: One-part elastomeric sealant formulated for use in a through-penetration fire-stop system for filling openings around duct penetrations through walls and floors, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.
3. Products: Subject to compliance with requirements, provide one of the following:

    a. "3M Fire Stop Foam"; 3M Corp.
    b. "SPECSEAL Pensil 200 Silicone Foam"; Specify Technology, Inc.
    c. 3M Fire Stop Sealant"; 3M Corp.
    d. "3M Fire Barrier Caulk CP-25"; Electrical Products Div./3M.
    e. "Fyre Putty"; Standard Oil Engineered Materials Co.
    f. "FS-ONE", Hilti, Inc.

J. Hangers and Supports

1. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
2. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:

    a. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
    b. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
    c. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
    d. Masonry Screw Type Anchors: Complying with ICC-ES AC106.
    e. Concrete Adhesive Type Anchors: Complying with ICC-ES AC308.

3. Building Attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
4. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.

    a. Hangers Installed In Corrosive Atmospheres: Electro-galvanized, all-thread rod or hot-dipped-galvanized rods with threads painted after installation.
    b. Straps and Rod Sizes: Conform with SMACNA HVAC Duct Construction Standards, 2005 Edition, for sheet steel width and gauge and steel rod diameters.

5. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
6. Trapeze and Riser Supports: Steel shapes conforming to ASTM A 36.

    a. Where galvanized steel ducts are installed, provide hot-dipped-galvanized steel shapes and plates.
    b. For stainless steel ducts, provide stainless steel support materials.
    c. For aluminum ducts, provide aluminum support materials, except where materials are electrolytically separated from ductwork.

7. Pre-engineered roof duct supports:

    a. Manufacturers:

        1) Cooper B-Line, Inc.
        2) Elite Components.

3) ERICO/Caddy.
4) Ferguson/FNW.
5) Miro.
6) PHD Manufacturing.
7) PHP Systems/Design.
8) Roof Top Blox.
9) Unistrut, a brand of Atkore International Inc.
10) Zsi Foster.

b. General: Pre-engineered devices with embedded duct support fixtures as specified.
c. Pedestals: Steel pedestals with thermoplastic or rubber base with the following dimensions:

1) Up to 12 inch strut length support: 18 inch x 18 inch.
2) Up to 16 inch strut length support: 24 inch x 18 inch.
3) Up to 24 inch strut length support: 30 inch x 18 inch.
4) Thickness: Minimum 3/16 inch thick.

d. Block Bases: Closed-cell polyethylene blocks with the following dimensions.

1) Length: Nominal 10 inch, 12 inch, 16 inch, or 24 inch
2) Width: Nominal 4 inches.

e. Attachment/Support Fixtures: As recommended by manufacturer, with straps or crossbar over top of duct to prevent movement.
f. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
g. Pre-Engineered Duct Support Rails:

1) Manufacturers:

a) AES Industries.
b) Custom Curb, Inc.
c) Pate Company.
d) Thybar.

2) Construction:

a) Base plate designed to be attached to building structure, with fully mitered raised cant and step to match roof insulation thickness.
b) Welded, minimum 18 gauge galvanized steel shell, internally reinforced to load bearing factors of equipment being supported.
c) Factory installed treated wood nailer.
d) 4 inch, minimum 18 gauge nailer jacket with counterflashing where equipment will not fully cover the support.

8. Wire Rope Hanging Systems:

a. General: Wire rope hanger system shall have a minimum 5 to 1 safety factor based upon the applied working load being supported.
b. Source Limitations: Furnish associated fittings, accessories, and hardware produced by a single manufacturer.
c. Wire Rope: Zinc coated or galvanized steel, with wire thread type as required to support the applied working load being supported. Provide same size wire for all applications based on worst case loading.

d. Cable Lock: Cast zinc housing with steel spring with wedge grip, selected to meet the vertical load applied to the hanging system and wire thread. Do not exceed the working load limit.
e. Accessories: Hanger attachments and structural attachments shall be compatible with wire rope hanger system and shall be by the same manufacturer as the wire rope hanger system.
f. Manufacturers:

1) ASC Engineered Solutions.
2) Ductmate Industries, Inc; Clutcher Cable Hanging System.
3) Duro Dyne.
4) Gripple.

K. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized steel reinforcing where installed on galvanized sheet metal ducts. For aluminum and stainless steel ducts provide reinforcing of compatible materials.

L. Tie Rods: Same material as the duct, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 DUCTWORK FABRICATION

A. Fabricate and support duct in accordance with latest edition of SMACNA (DCS).

B. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

1. Fabricate rectangular ductwork of minimum 26 gauge sheet metal.
2. Fabricate ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

C. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

D. Field Painted Ductwork: Provide mill phosphatized finish on exposed surfaces of rectangular ductwork and duct fittings to be field painted.

E. Exterior Ductwork: Ductwork installed exterior to the building without weather-proof jacket or cladding shall be minimum #18 gauge with longitudinal and transverse joints welded or sealed airtight as specified under Paragraph "Seam and Joint Sealing".

F. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20 gauge or less, with more than 10 sq. ft. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 2-9, unless they are lined or are externally insulated.

G. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 2005 Edition, Figures 4-1 through 4-8. Unless otherwise noted on drawings, provide prefabricated 45 degree, high efficiency, rectangular/round branch duct takeoff fittings with manual balancing damper, 3/8 inch square shaft, U-bolt, nylon bushings, locking quadrant, and 2 inch insulation build-out for branch duct connections and take-offs to individual diffusers, registers and grilles. 45 degree, high efficiency, rectangular/round branch duct takeoff fittings shall be Flexmaster STO with model BO3 damper or equal.

H. Provide radius elbows, turns, and offsets with a minimum centerline radius of 1-1/2 times the duct width. Where space does not permit full radius elbows, provide short radius elbows with a minimum of two continuous splitter vanes. Vanes shall be the entire length of the bend. The use of square throat, radius heel elbows is prohibited. Remove and replace all installed elbows of this type with an approved elbow at no additional cost to the owner.

I. Provide mitered elbows where space does not permit radius elbows, where shown on the drawings, or at the option of the contractor with the engineer's approval. The contractor shall obtain approval to substitute mitered elbows in lieu of radius elbows prior to fitting fabrication. Mitered elbows less than 45 degrees shall not require turning vanes. Mitered elbows 45-degrees and greater shall have single thickness turning vanes of same material and gauge as ductwork, rigidly fastened with guide strips in ductwork. Vanes for mitered elbows shall be provided in all supply and exhaust ductwork and in return and outside air ductwork that has an air velocity exceeding 1000 fpm. Do not install vanes in grease ductwork. Refer to Section "Ductwork Accessories" for turning vane construction and mounting.

J. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

K. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

L. Round and Flat Oval Duct Fabrication

1. General: "Basic Round Diameter" as used in this article is the diameter of the size of round duct that has a circumference equal to the perimeter of a given sized of flat oval duct. Except where interrupted by fittings, provide round and flat oval ducts in lengths not less than 12 feet.

    a. Fabricate round and flat oval ductwork of minimum 26 gauge sheet metal.

M. Round Ducts: Fabricate round supply ducts using seam types identified in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 3-2, RL-1, RL-4, or RL-5 except where diameters exceed 72 inches. Seam Types RL-2 or RL-3 may be used for ducts smaller than 72 inches in diameter if spot-welded on 1-inch intervals. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams. Comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Table 3-5 through 3-13 for galvanized steel gauges. For round duct with static pressure classification of 2 inches water gauge or lower, round supply ducts may be fabricated using snaplock seam types identified in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 3-2, RL-6A, RL-6B, RL-7 or RL-8.

N. Round and Flat Oval Fittings Fabrication

1. 90-Degree Tees and Laterals and Conical Tees: Fabricate to conform to SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figures 3-5, 3-6 and 3-7 and with metal thickness specified for longitudinal seam straight duct.
2. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from the body onto branch tap entrance.
3. Elbows: Unless elbow construction type is indicated, provide elbows meeting the following requirements:

    a. Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate the bend radius of die-formed, gored, and pleated elbows 1.5 times the elbow diameter.

1) Elbows in Round Duct: Provide full radius elbows.
2) Elbows in Flat Oval Duct: Provide full radius elbows. Where space limits the installation of full radius elbows, short radius elbows with a minimum of two continuous splitter vanes shall be installed. Vane length shall be the entire length of the bend or 36 inches whichever is greater.
3) The use of square throat, radius heel elbows is prohibited. Remove and replace all installed elbows of this type with an approved elbow at no additional cost to the owner.
4) Provide full radius elbows for ductwork installed in noise critical spaces or where shown on the drawings. Refer to Section "Basic Mechanical Materials and Methods" for noise critical spaces.

b. Mitered Elbows: Fabricate mitered elbows with welded construction in gauges specified below.

1) Mitered Elbows Radius and Number of Pieces: Unless otherwise indicated, construct elbow to comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Table 3-1.
2) Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from minus 2 inches to plus 2 inches:

a) 3 to 26 inches: 24 gauge.
b) 27 to 36 inches: 22 gauge.
c) 37 to 50 inches: 20 gauge.
d) 52 to 60 inches: 18 gauge.
e) 62 to 84 inches: 16 gauge.

3) Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from 2 inches to 10 inches:

a) 3 to 14 inches: 24 gauge.
b) 15 to 26 inches: 22 gauge.
c) 27 to 50 inches: 20 gauge.
d) 52 to 60 inches: 18 gauge.
e) 62 to 84 inches: 16 gauge.

4) Flat Oval Mitered Elbows: Solid welded and with the same metal thickness as
5) 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material handling classes A and B; and only where space restrictions do not permit the use of 1.5 bend radius elbows. Fabricate with a single-thickness turning vane.

c. Round Elbows - 8 Inches and Smaller: Die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g. 3-1/2- and 4-1/2-inch) elbows with gored construction.
d. Round Elbows - 9 Through 14 Inches: Gored or pleated elbows for 30, 45, 60, and 90 degrees, except where space restrictions require a mitered elbow. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g. 9-1/2- and 10-1/2-inch) elbows with gored construction.
e. Round Elbows - Larger Than 14 Inches and All Flat Oval Elbows: Gored elbows, except where space restrictions require a mitered elbow.
f. Die-Formed Elbows for Sizes Through 8 Inches and All Pressures: 20 gauge with 2-piece welded construction.
g. Round Gored Elbows Gauges: Same as for non-elbow fittings specified above.

h. Pleated Elbows Sizes Through 14 Inches and Pressures Through 10 Inches: 26 gauge.

4. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:

a. Round Elbows 4 to 8 Inches: 2-piece, die stamped, with longitudinal seams spot welded, bonded, and painted with a PVC aerosol spray.
b. Round Elbows 9 to 26 Inches: Standing seam construction.
c. Round Elbows 28 to 60 Inches: Standard gore construction, riveted and bonded.
d. Other Fittings: Riveted and bonded joints.
e. Couplings: Slip-joint construction with a minimum of a 2-inch insertion length.

O. Shop Application of Liner in Rectangular Ducts

1. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
2. Apply a coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
3. Butt transverse joints without gaps and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
5. Longitudinal joints in rectangular ducts shall not occur except at corners of ducts, unless the size of the duct and standard liner product dimensions make longitudinal joints necessary.

a. Apply an adhesive coating on longitudinal seams in ducts exceeding 2,500 FPM air velocity.

6. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
7. Secure transversely oriented liner edges facing the airstream with metal nosings that are either channel or "Z" profile or are integrally formed from the duct wall at the following locations:

a. Fan discharge.
b. Intervals of lined duct preceding unlined duct.
c. Upstream edges of transverse joints in ducts where duct velocity is greater than 2,500 FPM.

8. Terminate liner with duct buildouts installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to the duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire damper sleeve through fire separation.

2.4 MANUFACTURED DUCTWORK AND FITTINGS

A. General: At the Contractor's option, factory-manufactured ductwork can be provided instead of fabricated ductwork for round and oval ductwork. The round duct system shall consist of fittings that are factory fitted with a sealing gasket and spiral duct which, when installed according to the manufacturer's instructions, will seal the duct joints without the use of duct sealer. The oval duct system shall be sealed with duct sealer as specified.

1. Ducts shall be calibrated to manufacturer's published dimensional tolerance standard.

2. Spiral seam slippage shall be prevented by means of a flat seam and a mechanically formed indentation evenly spaced along the spiral seam.
3. Ducts shall be constructed using spiral lock seam sheet metal construction.
4. Ductwork to be installed in exposed locations shall have the surface prepared in the factory for field painting.

B. Duct Construction

1. Unless otherwise noted, all duct and fittings shall be constructed from galvanized steel in accordance with SMACNA's Duct Construction Standards for +10" water gauge pressure with minimum wall thickness as shown in the following tables:

Single Wall Round Duct:

Diameter (Inches)	Galvanized Spiral Duct (ga)	Galvanized Fittings (ga)
3-14	28	24
15-24	26	24
26-42	24	22
42-60	22	20

Double Wall Round Duct:

Diameter (Inches)	Galvanized Spiral Duct (ga)		Galvanized Fittings (ga)	
	Inner	Outer	Inner	Outer
3-14	28	28	24	24
16-24	26	26	24	24
26-42	24	24	22	22
44-60	22	22	20	20

Oval Duct:

Major Axis (Inches)	Galvanized Spiral Duct (ga)	Galvanized Fittings (ga)
3-24	24	20
25-38	22	20
37-48	22	18
49-60	20	18
61-70	20	16
71 and large	18	16

2. Duct shall be calibrated to manufacturer's published dimensional tolerance standard.
3. Ducts shall be constructed using spiral lock seam sheet metal construction.
4. Ductwork to be installed in exposed locations shall be factory-prepared for field painting, i.e. mill-phosphatized..

C. Fittings:

1. All fitting ends for round duct and transitions and divided flow fittings smaller than 24" diameter that convert oval duct to round duct shall come factory equipped with a double lipped, U-profile, EPDM rubber gasket. Gasket shall be manufactured to gauge and flexibility so as to ensure that system will meet all of the performance criteria set forth in the manufacturer's literature. Gasket shall be classified by Underwriter's Laboratories to

conform to ASTM E84-91a and NFPA 90A flame spread and smoke developed ratings of 25/50.

2. All fittings shall be calibrated to manufacturer's published dimensional tolerance standard and associated spiral duct.
3. All fitting ends from 5" to 60" diameter shall have rolled over edges for added strength and rigidity.
4. All elbows from 5" to 12" diameter shall be 2 piece die stamped and continuously stitch welded. All elbows 14" diameter and larger shall be standing seam gorelock construction and internally sealed.
5. The radius of all 90° and 45° elbows shall be 1.5 times the elbow diameter, unless otherwise noted on the contract documents to be 1.0. The radius of all 15°, 30° and 60° elbows shall be minimum 1.0 times the elbow diameter.
6. All fittings that are of either spot welded or button punched construction shall be internally sealed. When contract documents require divided flow fittings, only full body fittings will be accepted. The use of duct taps is unacceptable except for retrofit installations.
7. Double wall duct and fittings shall consist of a perforated or solid inner liner, a 1 inch, 1.50 pounds per cubic foot (unless otherwise specified) layer of fiberglass insulation and a solid outer pressure shell. Perforated inner liner shall have a retaining fabric wrapped between the perforated inner and the fiberglass insulation. This fabric shall provide fiberglass tear retention while maintaining the desired acoustical properties. For 1 inch thick insulation, the outer pressure shell diameter shall be 2 inches larger than the inner liner.
8. All double wall fittings for round duct shall be furnished with the manufacturer's standard gasket on the outer shell. The inner shell on all double wall fittings shall extend a minimum of 1 inch past the outer shell.
9. Double wall to single wall transitions shall be provided where insulated duct connects to non-insulated, single wall duct. Transitions shall also act as insulation ends reducing the double wall outer shell diameter to the inner shell diameter.
10. All double wall duct and fittings shall be furnished with both an inner liner and an outer pressure shell coupling. The inner liners shall not be fastened tighter to allow for expansion and contraction.
11. All volume dampers shall be Lindab Safe type DRU, DSU or DTU or equal by an acceptable manufacturer. Damper shall be fitting sized to slip into spiral duct. Damper shall be clearly visible and adjustable outside of duct wrap. Damper shall have the following features:

    a. Locking quadrant with blade position indicator.
    b. 2" sheet metal insulation stand-off.
    c. Integral shaft/blade assembly.
    d. Shaft mounted, load bearing bushings.
    e. Gasketed shaft penetrations to minimize leakage.

D. Manufacturers:

1. Hercules Industries.
2. Lewis & Lambert.
3. Lindab Safe.
4. Linx Industries, Inc.
5. Semco.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install, support, and seal ducts in accordance with SMACNA (DCS).

B. Install products in accordance with manufacturer's instructions.

C. Install ducts with the fewest possible joints.

D. Seal duct joints with the appropriate sealing material.

E. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

F. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

G. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Provide clearance of 1 inch where furring is shown for enclosure or concealment of ducts, plus allowance for insulation thickness, if any.

J. Install insulated ducts with 1-inch clearance outside of insulation.

K. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown.

L. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

M. Exposed Ductwork: Exposed ductwork shall be free of defects, dents or blemished surfaces to provide a smooth, finished appearance. Any damaged material shall be replaced with new material. Ductwork that is to be field painted shall have surfaces wiped clean of lubricant, dirt, or fil prior to priming and painting. Apply primer and paint of type as recommended by paint manufacturer for duct material and finish.

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

O. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1-1/2 inches.

P. Cover ducts openings during construction with duct caps or three-mil plastic to protect inside of (installed and delivered) ductwork from exposure to dust, dirt, paint and moisture. Do not use duct tape on ducts that will be exposed or painted.

Q. Duct Liner Installation

1. Fiberglass Duct Liner:

a. Attach fiberglass duct liner using fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 50-pound tensile dead load test perpendicular to the duct wall.

2. Flexible Elastomeric Duct Liner:

    a. Install liner in accordance with the manufacturer's installation instructions or ASTM C 1710.
    b. Attach flexible elastomeric duct liner to clean, oil-free sheet metal surfaces with adhesive as recommended by the liner manufacturer.
    c. Seal all longitudinal seams and end joints with manufacturer's recommended adhesive and install compression joints in accordance with manufacturer's instructions to eliminate any openings in insulation that would allow passage of air to duct surface being insulated.

R. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

S. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

T. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.

U. Seam and Joint Sealing

1. General: Seal duct seams and joints as follows:

    a. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed to meet SMACNA Seal Class A.
    b. Seal class shall apply to all supply, return, outdoor air, and exhaust ductwork, regardless if the duct is positively or negatively pressurized. Transfer air ducts and sound boots do not need to be sealed.

2. Seal externally insulated ducts prior to insulation installation.
3. Ductwork installed exterior to the building shall have longitudinal and transverse joints welded or sealed airtight with weatherproof heavy liquid sealant applied according to manufacturer's instructions.

V. HANGING AND SUPPORTING

1. Install rigid round, rectangular, and flat oval metal duct with support systems per SMACNA standards.
2. The use of wire rope hanging systems is an acceptable alternate hanging method when installed in strict accordance with manufacturer's instructions. Wire rope hanger spacing shall not exceed 8 feet. Supported load shall not exceed manufacturer's recommended load rating.

    a. Where approved by local code authority, the loop system may be swaged directly on to a seismic approved bracket or appropriate end fixing.

3. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.
4. Support vertical ducts at a maximum interval of 16 feet and at each floor.
5. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load but are not limited to the specific methods indicated. Hangers and

supports shall be fastened to building joists or beams. Do not attach hangers and supports to the above floor slab or roof with sheet metal screws.

6. Install concrete insert prior to placing concrete.
7. Install powder actuated concrete fasteners after concrete is placed and completely cured.
8. Provide double nuts and lock washers on threaded rod supports.
9. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

W. Penetrations

1. Fire Barrier Penetrations: Where ducts pass though fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity.
2. Exterior Wall Penetrations: Seal duct penetrations through exterior wall constructions with sleeves, packing, and sealant. Refer to Division 23 Section "Basic Piping Materials and Methods" for additional information.
3. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of No-Fire Rated Walls and Concrete Slab on Grade Penetrations: Seal ducts that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade. Refer to Division 23 Section "Basic Piping Materials and Methods" for special sealers and materials.

X. CONNECTIONS

1. Equipment Connections: Connect equipment with flexible connectors in accordance with Division 23 Section "Air Duct Accessories."
2. Branch Connections: Comply with SMACNA "HVAC Duct Construction Standards".
3. Outlet and Inlet Connections: Comply with SMACNA "HVAC Duct Construction Standards". Where a 90-degree elbow is required at the connection to air devices, provide a rigid duct elbow or, at Contractor's option, a flexible elbow assembly as specified in Division 23 Section "Air Duct Accessories."
4. Fan Connections: Comply with SMACNA "HVAC Duct Construction Standards".

3.2 FIELD QUALITY CONTROL

A. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.

B. General Duct Systems: Perform leakage tests in accordance with ASHRAE and SMACNA standards.

1. Disassemble, reassemble, and seal segments of the systems as required to accommodate leakage testing, and as required for compliance with test requirements.
2. Conduct tests, in the presence of the Architect, at static pressures equal to the maximum design pressure of the system or the section being tested. If pressure classifications are not indicated, test entire system at the maximum system design pressure. Do not pressurize systems above the maximum design operating pressure. Give 7 days' advanced notice for testing. Submit a letter report to the Owner and Engineer summarizing the test procedures followed, systems tested and the results of the leakage tests.
3. Determine leakage from entire system or section of the system by relating leakage to the surface area of the test section.
4. Maximum Allowable Leakage: As described in ASHRAE 2005 Handbook, "Fundamentals" Volume, Chapter 35, Table 9 and Figure 13. Comply with requirements for leakage classification 3 for round and flat oval ducts, leakage classification 12 for rectangular ducts

in pressure classifications less than and equal to 2 inches water gauge (both positive and negative pressures), and leakage classification 6 for pressure classifications greater than 2 inches water gauge and less than and equal to 10 inches water gauge.

5. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.
6. Leakage Test: Perform volumetric measurements and adjust air systems as described in ASHRAE 2003 "HVAC Applications" Volume, Chapter 37 and ASHRAE 2005 "Fundamentals" Volume, Chapter 14, and Division 23 Section "TESTING, ADJUSTING, AND BALANCING FOR HVAC."

C. Ductwork with Pressure Rating > 3" W.C.: Ducts and plenums shall be leak tested in accordance with SMACNA HVAC Air Duct Leakage Test Manual to prove they meet leakage classification less than or equal to 6. Submit test reports to the Engineer of Record demonstrating that at least 25 percent of the installed duct area has been tested and pass this test.

3.3 ADJUSTING, STARTUP AND CLEANING

A. Adjust volume control devices as required by the testing and balancing procedures to achieve required air flow. Refer to Division 23 Section "TESTING, ADJUSTING, AND BALANCING FOR HVAC" for requirements and procedures for adjusting and balancing air systems.

B. Vacuum duct systems prior to final acceptance to remove dust and debris.

C. Remove temporary protection devices over ductwork prior to starting equipment and turning the system over to the owner.

D. If permanent HVAC equipment is used during the construction period, provide temporary filters at all openings in the ductwork and at inside equipment to protect the system from dust, dirt, paint, and moisture. Replace and maintain filters when needed, but not less than every month. On the day of substantial completion, clean the duct system and provide a new set of filters in the HVAC unit.

1. Refer to Division 23 Section 234100 Particulate Air Filtration for filter requirements.

3.4 CLEANING NEW SYSTEMS

A. Contractor shall clean the HVAC systems in accordance with NADCA.

B. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

C. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.

    a. Do not degrade structural, thermal or functional system integrity of the duct.
    b. Provide access doors complying with UL 181 to cover new openings. Refer to Division 23 Section "Air Duct Accessories".
    c. Seal openings with tape and sealant complying with UL 181A.

2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

D. Vent vacuuming system to the outside. Provide filtration and/or containment systems to keep debris removed from HVAC systems from contaminating other spaces. Locate exhaust down wind and away from air intakes and other points of entry into building.

E. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply and outdoor air ducts, dampers, actuators, and turning vanes.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment while the system is under negative pressure; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to ACR 2002. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

G. Disposal: Debris collected from the HVAC system shall be disposed of in accordance with applicable federal, state and local requirements.

H. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and re-inspect ducts.

3.5 CLEANING EXISTING SYSTEMS

A. Contractor shall clean the HVAC systems in accordance with NADCA.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Use existing service openings where possible.
2. Create other openings to comply with duct standards.

a. Do not degrade structural, thermal or functional system integrity of the duct.
b. Provide access doors complying with UL 181 to cover new openings. Refer to Division 23 Section "Air Duct Accessories".
c. Seal openings with tape and sealant complying with UL 181A.

3. Disconnect flexible ducts as needed for cleaning and inspection.
4. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
5. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
2. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.

E. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply and outdoor air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment while the system is under negative pressure; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to ACR 2002. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide operative drainage system for wash down procedures.
7. Biocidal Agents and Coatings: Apply biocidal agents, Design Polymer DP 2545, Foster 40-20 or approved equal, if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

G. Disposal: Debris collected from the HVAC system shall be disposed of in accordance with applicable federal, state and local requirements.

H. Cleanliness Verification:

1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
2. Visually inspect metal ducts for contaminants.
3. Where contaminants are discovered, re-clean and re-inspect ducts.

I. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

1. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
2. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.

J. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Turning vanes.

B. Backdraft dampers.

C. Duct access doors.

D. Duct hardware.

E. Fire dampers.

F. Flexible duct connectors.

G. Volume control dampers.

H. Duct opening closure film.

I. Cable operated damper systems.

J. Flexible ductwork.

1.2 REFERENCE STANDARDS

A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.

B. ASTM A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. ASTM E477 - Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

E. ASTM E814 - Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops.

F. ASTM E 2336 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.

G. ISO 6944 - Fire Containment — Elements of Building Construction.

H. - Standard for the Installation of Air-Conditioning and Ventilating Systems.

I. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

J. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

K. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

L. UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.

M. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

N. UL 181 - Factory-Made Air Ducts and Connections.

O. UL 263 - Standard for Fire Tests of Building Construction and Materials; Current Edition, Including All Revisions.

P. UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.

Q. UL 1479 - Fire Tests of Through-Penetration Firestops.

1.3 SUBMITTALS

A. Product Data: Provide for each type of ductwork accessory the following:

1. Electrical characteristics.
2. Connection requirements.
3. Dimensions.
4. Capacities
5. Materials of construction.

B. Shop Drawings: Indicate for shop fabricated assemblies the following:

1. Interfacing requirements with ductwork.
2. Method of fastening or support.
3. Methods of assembly of components.

C. Performance Data: Submit performance data for duct silencers including insertion loss performance in octave bands from 63 Hz to 8,000 Hz and pressure drop at specified airflow.

D. Project Record Drawings: Record actual locations of access doors and test holes.

E. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual.

1.4 QUALITY ASSURANCE

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

B. SMACNA Compliance: Comply with applicable portions of SMACNA (DCS).

C. UL Compliance:

1. Fire Dampers: Construct, test, and label fire dampers in accordance with current edition of UL Standard 555.
2. Flexible Ductwork: Construct flexible ductwork in compliance with UL Standard 181.
3. Duct Tape: Label in accordance with UL Standard 181B and marked 181B-FX.
4. Duct Clamps: Label in accordance with UL Standard 181B and marked 181B-C.

D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated

E. NFPA Compliance:

1. Comply with applicable provisions of NFPA 90A and NFPA 90Bpertaining to installation of ductwork accessories.

F. ASTM Compliance: Products shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 "Surface Burning Characteristics" (NFPA 255) method.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork accessories during shipping and storage from dirt, debris and moisture damage.

B. Protect dampers from damage to operating linkages and blades.

1.6 SPARE PARTS

A. Extra Fusible Links: One link for every 10 installed of each type, size and temperature range. Obtain receipt.

PART 2 - PRODUCTS

2.1 TURNING VANES

A. Manufacturer:

1. Aero Dyne Co.
2. Anemostat Products Div.; Dynamics Corp. of America.
3. Ductmate Industries.
4. Duro Dyne Corp.
5. Elgen Manufacturing Co., Inc.
6. Hart & Cooley Mfg. Co.
7. Register & Grille Mfg. Co., Inc
8. Sheet Metal Connectors, Inc.

B. Manufactured Turning Vanes: Provide turning vanes and runners fabricated from galvanized sheet metal, lock-forming quality, ASTM A 653, minimum Coating Designation G 60, of the same gauge thickness or greater as the ductwork in which they are installed.

1. Vanes shall be rigidly fastened with guide strips to minimize noise and vibration.
2. Vanes in ductwork over 30" deep shall be installed in multiple sections with vanes not over 30" long and shall be rigidly fastened.
3. Turning vanes shall be constructed per SMACNA Duct Construction Standards Metal and Flexible – 2005 Edition, Figure 4-3 and set into side strips suitable for mounting in ductwork.

C. Acoustical Turning Vanes: Provide acoustical turning vanes constructed of airfoil shaped aluminum extrusion with perforated faces and fiberglass fill in systems serving noise critical spaces. Refer to Section "Common Work Results for HVAC" for noise critical spaces.

2.2 BACKDRAFT DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Arrow United Industries.
3. Cesco
4. Greenheck
5. Louvers & Dampers, Inc.
6. Nailor Industries, Inc.
7. Pottorff
8. Ruskin Mfg. Co.
9. TAMCO
10. Vent Products

B. Backdraft Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to open at indicated static pressure. Provide adjustment device to permit setting for varying differential static pressure

1. Construct frames of minimum16 gauge galvanized steel or 10 gauge aluminum.
2. Construct blades of minimum 16 gauge aluminum.
3. Provide minimum 1/2" diameter, corrosion-resistant bearings and 1/2" diameter, galvanized or stainless steel axles.
4. Mechanically lock blade edge seals into blade edge. Provide neoprene seals for round dampers and silicone or vinyl seals for rectangular dampers.

2.3 DUCT ACCESS DOORS

A. Manufacturers:

1. Air Balance Inc.
2. Ductmate Industries.
3. Duro Dyne Corp.
4. Greenheck.
5. Register & Grille Mfg. Co., Inc.
6. Ruskin Mfg. Co.
7. Ventifabrics, Inc.
8. Vent Products.
9. Zurn Industries, Inc.; Air Systems Div.

B. Provide, where indicated on the drawings or where specified in Part 3 of this section, duct access doors of size allowable by duct dimensions with, unless otherwise noted on the drawings, minimum size of 10" by 10" and maximum size of 24" by 24". Fabricate in accordance with SMACNA (DCS) and as indicated. Label access doors for fire and smoke dampers as specified in Part 3.

C. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. Construct of same or greater gauge as ductwork served. For insulated ductwork.

install minimum 1 inch thick insulation with sheet metal cover. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct.

1. 12 inches square or less: Provide one size hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors. Provide removable section of duct where duct size is too small for a 10" by 10" access door.
2. Larger than 12 inches square: Provide two hinges and two handle-type latches.

2.4 DUCT HARDWARE

A. Manufacturers:

1. Ductmate Industries.
2. Elgen Manufacturing Co., Inc.
3. Ventfabrics, Inc.
4. Young Regulator Co.

B. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated.

1. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
2. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

C. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.5 FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Cesco Products.
3. Greenheck
4. Louvers & Dampers, Inc.
5. Nailor Industries, Inc.
6. Pottorff
7. Prefco Products, Inc.
8. Ruskin Mfg. Co.

B. General: Provide fire dampers at locations indicated on the drawings. Damper ratings shall be as required to maintain the fire ratings noted on the architectural drawings. Provide duct access door for inspection and service to each fire damper and fusible link as required. Provide sleeves of length as required to meet the installed location.

C. Fabricate in accordance with NFPA 90A and UL 555 and as indicated.

D. Fire dampers shall be dynamic-rated for closure under pressure.

E. Provide positive lock in closed position.

F. Horizontal Dampers: Minimum 22 gauge galvanized steel frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket. Construct casings of 20 gauge stainless steel where installed in corrosive or moisture laden airstreams or where noted on the drawings.

G. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream. Construct frames of 20-gauge stainless steel where installed in corrosive or moisture laden airstreams or where noted on the drawings.

H. Fusible links: UL 33 rated at 160 to 165 degrees F unless otherwise indicated.

I. Accessories:.

2.6 FLEXIBLE DUCT CONNECTORS

A. Manufacturers:

1. Carlisle HVAC Products.
2. Ductmate Industries.
3. Duro Dyne Corp.
4. Elgen Manufacturing Co., Inc.
5. Ventfabrics, Inc.

B. Fabricate in accordance with SMACNA (DCS) and as indicated. Flexible connectors shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

C. Flexible Duct Connections: Fabric crimped into metal edging strip. Provide metal compatible with connected ducts. Factory fabricated. Flame-retardant or noncombustible fabrics compliant with NFPA 701.

1. Indoor Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric compliant with NFPA 90A.

   a. Minimum Weight: 26 oz./sq. yd.
   b. Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   c. Service Temperature: Minus 40 to plus 200 deg F.

2. Outdoor Fabric: UL listed fire-retardant woven glass fiber fabric coated with weatherproof, synthetic rubber resistant to UV rays and ozone compliant with NFPA 90A.

   a. Minimum Weight: 24 oz./sq. yd.
   b. Minimum Tensile Strength: 225 lbf/inch in the warp and 300 lbf/inch in the filling.
   c. Service Temperature: Minus 40 to plus 250 deg F.

3. Metal: Factory fabricated with a fabric strip minimum 3-1/2 inches wide attached to two strips of minimum 24 gauge galvanized sheet steel or 0.032-inch- thick aluminum.

D. Maximum Installed Length: 14 inch.

E. Coatings and Adhesives: Comply with UL 181, Class 1.

2.7 VOLUME CONTROL DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Arrow United Industries
3. Cesco
4. Greenheck
5. Louvers & Dampers, Inc.
6. Nailor Industries, Inc.
7. Pottorff
8. Rossi Air Flow
9. Ruskin Mfg. Co.
10. TAMCO
11. Vent Products

B. Fabricate dampers in accordance with SMACNA (DCS) and as indicated. Construct using galvanized steel for standard air systems, aluminum for wet or natatorium environments and stainless steel for corrosive environments.

C. Single Blade Dampers:

1. Fabricate for duct sizes up to 12 x 36 inch.
2. Blade: 20 gauge, 0.04 inch, minimum.

D. Multi-Blade Damper: Fabricate of parallel or opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

1. Blade: 18 gauge, 0.0478 inch, minimum.

E. Bearings: Corrosion resistant, molded synthetic.

F. Axles: Positively lock into the damper blade.

G. Blade Seals: Where used for shutoff duty, provide Neoprene seals for round dampers and silicone for rectangular dampers.

H. Quadrants:.

1. Provide locking, indicating quadrant regulators.
2. On insulated ducts, provide extended shafts and mount regulator on standoff bracket, base or adapter.
3. Where rod lengths exceed 48 inches, provide regulator at both ends.

2.8 DUCT OPENING CLOSURE FILM

A. Mold-resistant, self-adhesive film to keep debris out of ducts during construction.

B. Thickness: 2 mils.

C. High tack water-based adhesive.

D. UV stable.

E. Elongation Before Break: 325 percent, minimum.

2.9 CABLE OPERATED DAMPER SYSTEMS

A. Manufacturer:

1. DuroDyne, DuroZone.
2. Metropolitan Air Technology, Inc. (Reference model number for round damper is RT-250 and for rectangular damper is RT-200).
3. Young Regulator Co. (Reference model number is 270).

B. General: Where access to dampers through a hard ceiling is required, provide a concealed, remote cable-operated, butterfly-type volume damper assembly with external worm gear operator.

C. Damper assembly shall include duct casing with rolled bead stiffeners, reinforced blade, self-lubricating bearing, and remote operator mounting plate.

D. Adjustable through the diffuser frame with standard 1/4 inch nut-driver or flat screwdriver.

E. Cable assembly shall attach to damper as a single piece with no linkage adjustment required.

F. Positive, direct, two-way damper control with no sleeves, springs or screw adjustments to come loose after installation.

G. Cable length as required to span the distance from the damper to the remote operator location.

H. Where approved by Architect, a ceiling cup with cover plate can be used for access to cable operator.

2.10 FLEXIBLE DUCTWORK

A. Manufacturers:

1. ATCO Rubber Products.
2. Flexmaster.
3. JPL (J.P. Lamborn Co)
4. Thermaflex.

B. Construction: Provide flexible ductwork conforming to UL 181-Class I, NFPA 90A and NFPA 90B and as follows. Duct types of manufacturers are indicated for reference in regard to required quality of construction and materials.

C. Insulated Flexible Ductwork: Provide duct fabric of ply-vinyl film, polyethylene film or multiple layers of aluminum laminate supported by helically wound spring steel wire. Wrap fabric with fiberglass insulation and provide fire retardant polyethylene or reinforced metalized protective vapor barrier as specified herein.

1. Duct pressure class up to and including 6" w.g.

a. Fire retardant polyethylene vapor barrier

1) ATCO 80 Series
2) Flexmaster Type 5B
3) JPL Type PR Series
4) Thermaflex Type G-KM

b. Reinforced metalized vapor barrier

1) ATCO 30 Series
2) Flexmaster Type 5M
3) JPL Type MHP Series
4) Thermaflex Type M-KE

2. Flexible ductwork shall have CPE liner with steel wire helix mechanically locked or permanently bonded to the liner.
3. Provide acoustical, fiberglass insulated duct with minimum R-value of R-6.0.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Provide turning vanes, of same gauge as ductwork, rigidly fastened with guide strips in ductwork having an offset of 45 degrees or more. Provide vanes in all supply and exhaust ductwork and in return and outside air ductwork that has an air velocity exceeding 1000 fpm. Do not install vanes in grease or dryer exhaust ductwork.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated. Refer to plans for style of damper.

D. Provide combination fire and smoke dampers, fire dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by Authorities Having Jurisdiction.

1. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
2. Demonstrate re-setting of fire and fire/smoke dampers to Owner's representative.

E. Provide duct access doors to maintain and/or clean components internal to ductwork including, but not limited to, coils, airflow stations, motorized and backdraft dampers, humidifiers, etc, Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

1. Provide duct access doors in ductwork at the following locations

a. At each change in direction and at maximum 50-foot (15-m) spacing.
b. Upstream and downstream from turning vanes.

2. Provide duct access door(s) as scheduled below, at each fire and smoke damper within 12 inches of the device to allow for testing and maintenance. Label each door (with minimum 1" lettering) indicating which damper type is served. Door shall be capable of being fully opened or provide removable door.

DUCT ACCESS DOOR SCHEDULE

Duct Width/Depth	Door Size	Quantity
10" TO 12"	10 X 10	1
14" TO 18"	12 X 12	1
20" TO 36"	14 X 14	1
38" TO 54"	18 X 18	1
56" TO 72"	18 X 18	2 (1 EACH END)
74" TO 96"	20 X 20	2 (1 EACH END)

3. Provide duct access doors for cleaning kitchen exhaust ducts in accordance with NFPA 96. Review locations prior to fabrication.

F. Provide flexible duct connections wherever ductwork connects to vibrating equipment and when transitioning between two different metallic duct materials (e.g., aluminum to galvanized steel). Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibration of connected equipment.

1. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
2. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.

G. Provide volume control dampers at branch takeoffs from main ducts. Unless otherwise noted on drawings, provide prefabricated 45 degree, high efficiency, rectangular/round branch duct takeoff fittings with manual volume control damper and locking quadrant for branch duct connections and take-offs to individual diffusers, registers and grilles.

H. Provide cable operated volume dampers with remote operators where access to dampers through a hard ceiling is required.

1. Support cable assembly to avoid bends and kinks in cable.

I. Install flexible ductwork in accordance with manufacturer's instructions. At a minimum, install two wraps of duct tape around the inner core connection and a metallic or non-metallic clamp over the tape and two wraps of duct tape or a clamp over the outer jacket.

1. Flexible ductwork runs shall not exceed 5 feet in length. Utilize the minimum length of duct to make the connections.
2. Install flexible ductwork straight as possible avoiding tight turns with a maximum of one 90 degree bend in any length. Install flexible ductwork fully extended minimizing compression.
3. Provide continuous length with no intermediate joints.
4. Support flexible ductwork from structure and not from ceiling tile, light fixtures or air terminals. Support for maximum sag of 1/2-inch per foot.
5. Avoid incidental contact with metal fixtures, water lines, pipes, or conduit.
6. Support straps/saddles shall be minimum 1-1/4" wide. Use of wire hanging systems shall utilize strap and connect wire to strap.

a. Factory installed suspension systems are acceptable

7. Do not crimp flexible ductwork against joist or truss members, pipes, conduits, etc.
8. Install flexible ductwork with bend radius at the center line equal to or greater than one duct diameter.

    a. Support bends approximately one duct diameter on both sides of bends.

9. Connect flexible ductwork to sheet metal ductwork and air devices with at least 1" overlap.

J. Provide rigid duct elbow where a 90 degree elbow is required at connection to air devices.

K. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.3 FIELD QUALITY CONTROL

A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

B. After start-up, final corrections and balancing of systems, test duct silencers by taking octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations, as directed. Refer to Division 23 Section "Testing, Adjusting and Balancing of HVAC" for additional requirements.

1. Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements.
2. Submit complete report of test results including sound curves.

3.4 ADJUSTING AND CLEANING

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

B. Label access doors in accordance with Division-23 section "Identification for HVAC Piping and Equipment".

C. Final positioning of manual dampers is specified in Division-23 section "Testing, Adjusting, and Balancing for HVAC".

D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Upblast roof exhausters.

B. Inline centrifugal fans.

1.2 REFERENCE STANDARDS

A. AMCA 99 – Standards Handbook.

B. AMCA 204 – Balance Quality and Vibration Levels for Fans.

C. AMCA 210 – Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

D. AMCA 300 – Reverberant Room method for Sound Testing of Fans.

E. AMCA 301 – Certified Ratings Program Product Rating manual for Fan Sound Performance.

F. AMCA 311 – Certified Ratings Program Product Rating Manual for Fan Sound Performance.

G. NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

H. UL 705 – Power Ventilators; Current Edition Including all Revisions.

I. UL 762 – Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances; Current Edition Including all Revisions.

1.3 SUBMITTALS

A. General: Submit data in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements. Include the following:

1. For fans with factory-furnished starters or variable frequency drives, include short circuit current ratings.
2. Materials gages and finishes, including color charts.
3. Dampers, including housings, linkages, and operators.

C. Shop Drawings: Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

D. Wiring Diagrams: Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.

E. Maintenance Data: Include instructions for lubrication, motor and drive replacement and spare parts list.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Extra Fan Belts: One set for each individual fan.

1.4 QUALITY ASSURANCE

A. AMCA Compliance: Provide products that meet AMCA certified performance and sound ratings and are licensed to use the AMCA Seal.

B. UL Compliance: Fans and fan motors shall be designed, manufactured, and tested in accordance with UL 705 "Power Ventilators."

C. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

E. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.6 FIELD CONDITIONS

A. Permanent fans may not be used for ventilation during construction.

PART 2 - PRODUCTS AND MATERIALS

2.1 POWER VENTILATORS - GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished; with indicated capacities and characteristics.

B. Statically and Dynamically Balanced: Fans and shafts shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210.

D. Sound Ratings: Comply with AMCA 301. Test fans in accordance with AMCA Standard 300.

E. Fabrication: Comply with AMCA 99.

F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.4.

G. Belts: Oil-resistant, non-sparking, and non-static.

H. Motors: Refer to Section "Common Motor Requirements for HVAC Equipment" for requirements.

I. Motor and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

J. Factory Finish: The following finishes are required:

1. Sheet Metal Parts: Prime coating prior to final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.

2.2 UPBLAST ROOF EXHAUSTERS

A. Manufacturers:
1. Carnes Company, Inc.
2. Cook (Loren) Co.
3. Greenheck Fan Corp.
4. Hartzell Fan, Inc.
5. PennBarry.
6. Twin City Fan Company

B. General Description: Belt-driven or direct-drive as indicated, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Fan Wheel:

1. Type: Non-overloading centrifugal, propeller or axial blades as scheduled
2. Material: Aluminum ,

D. Housing:

1. Construct of heavy-gage aluminum including curb cap, windband and motor compartment..
2. Rigid internal support structure.
3. One-piece fabricated or fully welded curb-cap to windband for leak proof construction.
4. Wind Band and Base: Reinforced and braced aluminum, containing aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

a. Dampers Rods: Steel with bronze or nylon bearings.

5. Provide breather tube for fresh air motor cooling and wiring.

E. Shafts and Bearings:

1. Fan Shaft:

a. Ground and polished steel with anti-corrosive coating.
b. First critical speed at least 25 percent over maximum cataloged operating speed.

2. Bearings

a. Permanently sealed or pillow block type.
b. Minimum L10 life in excess of 50,000 hours.

F. Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
2. Belts: Static free and oil resistant.
3. Pulleys: Cast-iron, adjustable-pitch, keyed and securely attached to the wheel and motor shafts..

G. Roof Curbs: Refer to Section "Hangers and Supports for HVAC" for pre-engineered roof equipment supports.

H. Drain Trough: Provides single point drainage for water or other residue.

I. Accessories: Provide the following items as indicated:

1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
2. Bird Screens: Maximum 1/2-inch mesh, 16-gage aluminum or brass wire.
3. Dampers: Counter-balanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.

a. Blades: Die-formed sheet aluminum.
b. Frame: Extruded aluminum, with waterproof, felt blade bumpers.
c. Linkage: Nonferrous metals.
d. Operators: Manufacturer's standard electric actuator.

2.3 INLINE CENTRIFUGAL FANS

A. Manufacturers:
1. Carnes Company, Inc.
2. Cook (Loren) Co.
3. Greenheck Fan Corp.
4. PennBarry.
5. Twin City Fan Company

B. Fan Unit: Inline, belt or direct driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.

C. Housing: Galvanized steel or split, spun-aluminum housing, with straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Wheel: Aluminum, forward curved, backward inclined or airfoil blades welded to aluminum hub.

E. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.

F. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing. Provide self-aligning pre-lubricated ball bearings.

G. Accessories: Provide the following accessories as indicated:

1. Volume Control Damper: Manual operated with quadrant lock, located in fan outlet.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: Expanded metal in removable frame.
4. Speed Control: Variable speed switch with on-off control and speed control for 100 to 50 percent of fan air delivery.

PART 3 - EXECUTION

3.1 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of structural steel support members.

3.2 INSTALLATION

A. Install fans level and plumb, in accordance with manufacturer's written instructions.

B. Secure roof-mounted fans to pre-engineered roof equipment supports in accordance with the requirements specified in Section "Hangers and Supports for HVAC Piping and Equipment."

C. Cabinet Units: Suspend units from structural steel support frame using steel wire or metal straps.

D. Install vibration isolation for equipment as specified in Division 23 Section "Vibration Isolation for HVAC Piping and Equipment."

E. Arrange installation to provide access space around fans for service and maintenance.

3.3 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.4 STARTUP

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.
2. Verify fan assembly is secure on mountings and supporting devices and that connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

    a. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.
3. Shut unit down and reconnect automatic temperature control operators.
4. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for air-handling-system testing, adjusting, and balancing.

3.5 DEMONSTRATION

A. Demonstration Services: Train Owner's maintenance personnel on the following:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Closeout Procedures" and Division 23 Section "General Mechanical Requirements."

B. Schedule training with at least 7 days' advance notice.

END OF SECTION

SECTION 233713 - DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ceiling air diffusers.

B. Registers and grilles.

1.2 REFERENCE STANDARDS

A. ADC 1062 – Certification, Rating and Test Manual.

B. AHRI 880 – Performance Rating of Air Terminals.

C. AHRI 885 – Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets (with Addendum 1)

D. AMCA 500 – Test Method for Louvers, Dampers and Shutters.

E. ASHRAE 70 – Method of Testing the Performance of Air Outlets and Inlets.

F. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.

G. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems.

H. – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

I. UL 723 – Standard for Test for Surface Burning Characteristics of Building Materials.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details. Indicate selections on product data.
3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings at specified airflows.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

D. Coordination Drawings: Reflected ceiling plans and wall elevations drawn to scale to show locations and coordination of diffusers, registers, and grilles with other items installed in ceilings and walls.

E. Color Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for diffusers, registers, and grilles with factory-applied color finishes.

1.4 QUALITY ASSURANCE

A. Test and rate air outlets and inlets in accordance with ASHRAE 70.

B. Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062.

C. Provide air outlets and inlets bearing ADC Certified Rating Seal.

D. Test and rate sound data for air outlets and inlets in accordance with AHRI 885.

E. Install air outlets and inlets in accordance with NFPA 90A.

F. Test and rate louvers in accordance with AMCA 500.

1.5 SPARE PARTS

A. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

PART 2 - PRODUCTS

2.1 CEILING AIR DIFFUSERS

A. Manufacturers
1. Krueger Mfg. Co.
2. Metalaire; Metal Industries, Inc.
3. Nailor Industries, Inc.
4. Price Industries, Inc.
5. Titus HVAC
6. Tuttle & Bailey; Div. of Air Systems Components, Inc.

B. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and provided with accessories as required for a complete installation.

C. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

D. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

E. Types: Provide ceiling air diffusers of type, capacity, and with accessories and finishes as scheduled on the drawings.

2.2 REGISTERS AND GRILLES

A. Manufacturers
1. Krueger Mfg. Co.
2. Metalaire; Metal Industries, Inc.
3. Nailor Industries, Inc.
4. Price Industries, Inc.
5. Titus HVAC
6. Tuttle & Bailey; Div. of Air Systems Components, Inc.

B. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and provided with accessories as required for a complete installation.

C. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.

D. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

E. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as scheduled on the drawings.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which air outlets and inlets are to be installed for compliance with installation tolerances and conditions that would affect the performance of the equipment. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions, design drawings, referenced standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, to interface installation of air outlets and inlets with other work.

C. Where a 90-degree elbow is required at the connection to air devices, provide a rigid duct elbow or, at Contractor's option, a flexible elbow assembly as specified in Division 23 section "Air Duct Accessories".

D. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling module.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before beginning air balance.

3.4 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove dirt and smudges. Replace any air device that has damaged finishes.

END OF SECTION 233713

SECTION 234000 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Filter Gauges

1.2 REFERENCE STANDARDS

A. AHRI 850 – Performance Rating of Commercial and Industrial Air Filter Equipment.

B. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data including, dimensions, weights, required clearances and access, flow capacity including initial and final pressure drop at rated air flow, efficiency and test method, fire classification, and installation instructions.

B. Maintenance Data: Submit maintenance data and spare parts lists for each type of filter and rack required. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B, and NEC pertaining to installation of air filters and associated electric wiring and equipment.

B. UL Compliance:

1. Comply with UL Standards pertaining to safety performance of air filter units.

C. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.

D. AHRI Compliance: Comply with provisions of AHRI Standard 850 pertaining to test and performance of air filter units.

PART 2 - PRODUCTS AND MATERIALS

2.1 FILTER GAUGES

A. Manufacturers:

1. Dwyer Instruments, inc.
2. H.O. Trerice co.
3. Weiss Instruments
4. Wika USA

B. General: Provide separate gauge for each filter bank or gauge with sufficient range to serve all connected filters.

C. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range such that final filter pressure drop is near mid-range, 2 percent of full scale accuracy.

D. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum, plastic or copper tubing, 2- or 3-way vent valves, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions and comply with installation requirements as specified elsewhere in these specifications pertaining to air filters housing/casings, and associated supporting devices.

B. Install air filters and holding devices of types indicated, and where shown; in accordance with air filter manufacturer's written instructions and with recognized industry practices; to ensure that filters comply with requirements and serve intended purposes.

C. Coordinate with other work including ductwork and air handling unit work, as necessary to interface installation of filters properly with other work.

D. Install filters in proper position to prevent passage of unfiltered air.

E. Install air filter gauge pressure tips upstream and downstream of filters to indicate air pressure drop through air filter. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level inclined gauges if any, for proper readings.

3.2 FIELD QUALITY CONTROL

A. Cleaning:

1. Thoroughly clean any equipment that has been operated during the construction period.
2. Replace filters in any equipment that has operated during the construction period or that got dirty from the construction process.

END OF SECTION

SECTION 237413 - OUTDOOR PACKAGED HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged roof top unit.

B. Unit Controls.

C. Roof mounting curb and base.

1.2 REFERENCE STANDARDS

A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

B. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment.

C. AHRI 410 - Forced-Circulation Air- Cooling and Air-Heating Coils.

D. ASHRAE 15 - Safety Code for Mechanical Refrigeration.

E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

F. UL 1995 – Heating and Cooling Equipment.

1.3 SUBMITTALS

A. Product Data: Provide manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, and furnished specialties and accessories. Provide short circuit current rating of units with factory mounted starter or variable frequency drive.

B. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.

C. Shop Drawings:

D. Submit manufacturer's assembly-type shop drawings indicating dimensions, required clearances, and methods of assembly of components

1. Submit shop drawings detailing the mounting, securing, and flashing of the roof curb to the roof structure. Indicate coordinating requirements with roof membrane system.

E. Wiring Diagrams: Submit wiring diagrams detailing the manufacturer's electrical requirements for power supply wiring for rooftop heating and cooling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.

G. Operation and Maintenance Data: Submit maintenance data and parts list for each rooftop unit, including "trouble-shooting" maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual; in accordance with requirements of Division 1.

H. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.4 QUALITY ASSURANCE

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

B. Codes and Standards:

1. Gas-fired furnace section construction shall be in accordance with AGA safety standards. Furnace section shall bear the AGA label.
2. AHRI Compliance:
   a. Testing and rating of rooftop units under 135,000 btu/hr capacity shall be in accordance with AHRI 210 and provide Certified Rating Seal.
   b. Sound testing and rating of units shall be in accordance with AHRI 270. Units shall bear Certified Rating Seal.
3. Refrigerating system construction of rooftop units shall be in accordance with ASHRAE 15.
4. Rooftop units shall be listed by UL and have UL label as a unit.
5. Replacement parts including but not limited to motors, control boards, valves, and fan components shall be available from local suppliers. Manufacturer shall disclose foreign made parts within their bid that are not available from local stock.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept products, with factory-installed shipping skids and lifting lugs. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units. Inspect for damage.

B. Protect units from physical damage by storing off site or in locked, protected area until roof mounting curbs are in place, ready for immediate installation of units.

1.6 SPECIAL WARRANTY

A. Warranty on Compressor and Heat Exchanger: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors and heat exchangers with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Warranty Period: 5 years from date of substantial completion.

1.7 SPARE PARTS

A. General: Furnish to Owner, with receipt, the following spare parts for each rooftop heating and cooling unit.

1. One set of matched fan belts for each belt driven fan.
2. One set of spare filters of each type required for each unit. Obtain receipt from Owner that spare filters have been provided. In addition to the spare set of filters, install new filters at completion of installation work, and prior to testing, adjusting, and balancing work.
3. If HVAC equipment is used during the construction period, Contractor shall provide one set of filters (if system is designed to include pre-filters and after-filters, provide only pre-filters) when the unit is started and replace filters when needed, but not less than every month. On the day of substantial completion, the Contractor shall clean the unit and provide a new set of filters at each location in the unit.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS:

A. Refer to RTU schedule on plans.

2.2 MANUFACTURED UNITS

A. General: Roof or slab mounted units, factory assembled, prewired and tested,

B. Description: , Self-contained, packaged unit consisting of compressors, condensers, evaporator coils, heating system, condenser and evaporator fans, , refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics shall be as scheduled on the Drawings.

C. Refrigerant: Provide rooftop units designed to operate with refrigerant as scheduled on the drawings.

2.3 FABRICATION

A. Cabinet: Provide manufacturer's standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a knockouts for electrical and piping connections, and an exterior condensate drain connection, and lifting lugs.

1. Bottom Duct Connections: Provide steel or aluminum walking grate on structural supports where connections are located in sections accessible by personnel for maintenance.

B. Insulation: Minimum of 1" thick, 1.5 pound density thermal insulation.

C. Condensate Drain Pan: Provide galvanized or stainless steel condensate drain pan sloped to drain connection.

D. Filters Section: Provide filter housing of material matching the unit casing with gasketed filter media holding frames. Provide access panel large enough for filter replacement with continuous gasketing and positive locking devices.

E. Roof Curbs: Refer to Section "Hangers and Supports for HVAC" for pre-engineered roof equipment supports and Section "Vibration Isolation for HVAC Piping and Equipment" for vibration isolated equipment support bases.

2.4 FANS

A. Supply Fans: Provide forward-curved or backward inclined, centrifugal fan wheel, V-belt drive with adjustable variable pitch motor pulley or direct drive, rubber isolated hinge mounted high efficiency motor and permanently lubricated motor bearings.

B. Condenser Fans: Provide propeller-type, direct-driven fans, resiliently mounted with fan guard, with permanently lubricated bearings.

C. Power Exhaust Fan: Direct drive, propeller type designed for low tip speed. Motors shall be open drip-proof with internal motor protection and permanently lubricated ball bearings.

D. Variable Air Volume Control: Provide variable frequency drives to modulate fans to meet specified sequence of operation. Refer to Division 23 section "Variable Frequency Drives".

2.5 MOTORS:

A. Refer to Section "Common Motor Requirements for HVAC Equipment" for requirements.

2.6 AIR FILTRATION

A. Filters Section: Provide 2" thick fiberglass throwaway pleated filters in filter rack, with maximum face velocity of 400 fpm and minimum MERV rating per ASHRAE 52.2 of MERV 13.

2.7 GAS-FIRED HEAT EXCHANGERS:

A. Provide aluminized steel construction for gas-fired heat exchangers and burners with entering air temperatures higher than 50 F. Provide stainless steel construction for gas-fired heat exchangers and burners with entering air temperatures less than or equal to 50 F or have airstreams that are corrosive. Provide heat exchangers and burners designed for staged or modulating operation as scheduled or noted on the drawings with minimum efficiency of 80 percent. Provide single gas connection.

B. Gas Burner: Atmospheric or power-vented type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut-off pilot.

C. Operating Controls: Provide the following controls for the gas-fired heat exchangers:

1. Intermittent pilot ignition;
2. Electronic spark ignition system;
3. High limit cutout;
4. Forced draft proving switch;

5. Flame roll-out switch.

2.8 EVAPORATOR COIL

A. Provide copper tube aluminum fin coil assembly with galvanized drain pan and connection.

B. Provide equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant.

C. Provide interlaced coils in multiple stage units to ensure full coverage over coil face.

D. Coils shall be proof (450 psig) and leak (300 psig) tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of refrigerant.

E. Provide 1 inch factory installed flexible elastomeric insulation around the suction and liquid lines not directly located above a condensate drain pan. If any piping is exposed to sunlight, provide UV protective coating.

2.9 HOT GAS REHEAT COIL:

A. Provide hot gas reheat coil with staged or modulating control for reheat during dehumidification operation. Size hot gas reheat coil capacity to maintain space temperature when unit is operating in the dehumidification mode with no load in the space. Refer to control drawings.

2.10 COMPRESSORS:

A. Provide serviceable, semi-hermetic, or fully hermetic compressors, complete with integral vibration isolators, crankcase heaters which de-energize during compressor operation.

B. Units shall have the following capacity control measures to prevent excessive compressor short cycling and prevent evaporator coil from freezing:
1. Digital scroll or Inverter scroll compressor as the first stage.
2.

C. Accessories: Thermal expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves; minimum of 2 refrigerant circuits for units having 2 or more compressors.

2.11 CONDENSER COIL

A. Provide copper tube aluminum fin coil assembly with subcooling rows and coil guard.

B. Provide corrosion protective coating where scheduled.

C. Provide refrigerant pressure switches to cycle condenser fans

2.12 MIXED AIR CASING

A. General: Dampers and their operators shall comply with performance requirements specified in Division 23 Section "Instrumentation and Control Devices for HVAC."

B. Outdoor Air Damper:

1. Provide outside air damper constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven.
2. Refer to schedules and control diagrams on the drawings for quantity, capacity and control method of the outdoor air dampers of each unit.

C. Economizer Control:

1. Provide economizer system complete with return and outside air dampers, outside air filter, fully modulating electric control system with dry bulb or enthalpy control as noted on the drawings, and adjustable mixed-air thermostat.
2. System shall have 100 percent outside air capability.
3. Provide automatic changeover through adjustable control device.

2.13 OPERATING CONTROLS:

A. Provide solid-state control board and components that contain at a minimum the following features:

1. Indoor fan on/off delay.
2. Default control to ensure proper operation after power interruption.
3. Service relay output.
4. Unit diagnostics and diagnostic code storage.
5. Field-adjustable control parameters.
6. Dehumidification control with humidistat.
7. Economizer control.
8. Gas valve delay between first- and second-stage firing.
9. Gas valve modulation.
10. Indoor-air quality control with carbon dioxide sensor.
11. Minimum run time.
12. Night setback mode.
13. Return-air temperature limit.
14. Fan-proving switch to lock out unit if fan fails.
15. Dirty-filter switch.
16. Smoke alarm with smoke detector installed in ductwork as noted on the drawings.

2.14 SAFETY CONTROLS:

A. Provide safety controls for the following:

1. Low pressure cutout, manual reset type;
2. High pressure cutout, manual reset type;
3. Compressor motor overload protection, manual reset type;
4. Anti-recycling timing device;
5. Adjustable low-ambient lockout;
6. Oil pressure switch.

2.15 ELECTRICAL

A. Provide a 125 VAC, 20 amp duplex convenience receptacle mounted to unit ready for field wiring through the curb with a cover UL listed for wet and damp locations when in use.

B. Unit power connection shall be either through unit cabinet or within roof curb perimeter.

C. Rooftop units shall be designed to meet the minimum short-circuit withstand rating specified on the drawings.

2.16 ACCESSORIES

A. Units shall include the following accessories where scheduled or shown on the drawings:

1. Remote Control Panel: Furnish panel for remote mounting containing control of heating, cooling, evaporator fan, and outdoor damper; and indicator lights for up to 6 unit functions.
2. Anti-recycling control to automatically prevent compressor restart for 5-minutes after shutdown.
3. Low ambient control head pressure control, designed to operate at temperatures down to temperature specified on the drawings.
4. Provide guards to protect the condenser coil from hail or other damage.
5. Thermostat: Assembly shall provide for staged heating and cooling with manual or automatic changeover on standard subbase.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas and conditions under which rooftop units are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. For roof installed units, verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings..

D. Do not proceed with work until unsatisfactory conditions have been corrected

3.2 INSTALLATION OF ROOFTOP HEATING AND COOLING UNITS

A. General: Install rooftop units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Secure roof-mounted units to roof equipment supports and grade-mounted units to curbs or base.. Refer to the drawings for the type of support required for each rooftop unit..

1. Refer to Section "Hangers and Supports for HVAC Piping and Equipment" for standard roof curbs.
2. Refer to Section "Vibration Isolation For HVAC" for vibration isolation curbs.

C. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

D. Ductwork: Refer to Division-23 section "Metal Ducts". Connect supply and return ducts to unit with flexible duct connections. Provide transitions to exactly match unit duct connection size.

E. Piping: Piping installation requirements are specified in other Division 23 sections. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:

1. Condensate Drain Piping: Route condensate drain to nearest roof drain or to location shown on the drawings. Provide trap at connection to drain pan with depth as noted on the drawings and install cleanouts at changes in direction (refer to manufacturer's recommendations for any additional requirements). Size condensate drain piping in accordance with local code and as shown on the drawings.

F. Connect gas piping to gas-fired heat exchanger according to requirements of Division 22 section "Natural Gas Systems." Provide union with sufficient clearance for burner removal and service.

3.3 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust fan for required airflow in accordance with Section "Testing, Adjusting and Balancing for HVAC." Tighten belts as required for proper operation.

B. Adjust damper linkages for proper damper operation.

C. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, intake plenum cabinet, heat exchange surfaces, cooling/heating coil sections, filter sections, access sections, etc.

3.4 STARTUP

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping, blocking, and bracing.
2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set outside-air and return-air mixing dampers to minimum outside-air setting.
7. Comb coil fins for parallel orientation.
8. Install clean filters. Do not operate air handling unit without pre-filters installed.
9. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.
10. Disable automatic temperature control operators.

B. Start-Up Services: Provide the services of a factory-authorized service representative to start-up rooftop units in accordance with manufacturer's written start-up instructions. Do not operate units without filters installed. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

1. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

a. Replace fan and motor pulleys as required to achieve design conditions.
b. Measure and record motor electrical values for voltage and amperage.
c. Shut unit down and reconnect automatic temperature control operators.
d. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for system testing, adjusting, and balancing.

3.5 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of two hours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

SECTION 237433 - DEDICATED OUTDOOR AIR UNITS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. Section includes package units capable of supplying 100 percent outdoor air.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions. Provide short circuit current rating of units with factory mounted starter or variable frequency drive.

B. Shop Drawings:

1. Submit manufacturer's assembly-type shop drawings indicating dimensions, required clearances, and methods of assembly of components
2. Submit shop drawings detailing the mounting, securing, and flashing of the roof curb to the roof structure. Indicate coordinating requirements with roof membrane system.

C. Wiring Diagrams: Submit wiring diagrams detailing the manufacturer's electrical requirements for power supply wiring for rooftop heating and cooling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Operation and Maintenance Data: Submit maintenance data and parts list for each rooftop unit, including "trouble-shooting" maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in maintenance manual; in accordance with requirements of Division 1.

1.3 QUALITY ASSURANCE

A. Codes and Standards:

1. Gas-fired furnace section construction shall be in accordance with AGA safety standards. Furnace section shall bear the AGA label.
2. AHRI Compliance:

a. Testing and rating of rooftop units of 135,000 btu/hr capacity or over shall be in accordance with AHRI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".
   a. Capacity ratings for air-to-air energy recovery equipment shall comply with AHRI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
   b. Sound testing and rating of units shall be in accordance with AHRI 270 "Standard for Sound Rating of Outdoor Unitary Equipment". Units shall bear Certified Rating Seal.

3. Refrigerating system construction of dedicated outdoor air units shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
4. Energy Efficiency Ratio (EER) of dedicated outdoor air units shall be equal to or greater than prescribed by ASHRAE 90.1-2004 "Energy Standard For Buildings Except Low-Rise Residential Buildings".
5. Dedicated outdoor air units shall be listed by UL and have UL label as a unit.
6. Dedicated outdoor air units shall be designed, manufactured, and tested in accordance with UL requirements.

1.4 SPARE PARTS

A. General: Furnish to Owner, with receipt, the following spare parts for each dedicated outdoor air unit.

1. One set of matched fan belts for each belt driven fan.
2. If HVAC equipment is used during the construction period, Contractor shall provide one set of filters (if system is designed to include pre-filters and after-filters, provide only pre-filters) when the unit is started and replace filters when needed, but not less than every month. On the day of substantial completion, the Contractor shall clean the unit and provide a new set of filters at each location in the unit.

1.5 SPECIAL WARRANTY

A. Warranty on Compressor and Heat Exchanger: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors and heat exchangers with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Warranty Period: 5 years from date of substantial completion.

PART 2 - PRODUCTS AND MATERIALS

2.1 DEDICATED OUTDOOR AIR UNITS (ALL SIZES)

A. Manufacturers: Subject to compliance with requirements, provide dedicated outdoor air units of one of the following:
1. Refer to RTU schedule on plans.
2. Valent Air Management Systems.

B. General Description: Units shall be factory-assembled and tested, designed for roof or slab installation, and consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics shall be as scheduled on the Drawings.

C. Casing: Provide manufacturer's standard double wall casing construction with fiberglass or foam-injected insulation that provides a minimum R-6 R value. The manufacturer's standard cabinet construction shall incorporate a thermal break such that there is no through metal path between the interior and exterior surface of the unit casing at all panel frames, joining mullions, or corners.

Casing shall have corrosion protection coating and exterior finish that meets ASTM B117 salt spray test of minimum 500 hours. Casings shall have removable panels or access doors for inspection and access to internal parts, knockouts for electrical and piping connections and an exterior condensate drain connection and lifting lugs.

1. Bottom Duct Connections: Provide steel or aluminum walking grate on structural supports where connections are located in sections accessible by personnel for maintenance.

D. Roof Curbs: Provide manufacturer's standard construction, insulated and having corrosive protective coating, complete with factory-installed wood nailer and drain nipple. Construction shall be in accordance with NRCA Standards.

1. Overall roof curb height shall be the greater of the following:

   a. Minimum 12 inches for roofs with no insulation.
   b. Minimum 15 inches for roofs with insulation.
   c. As scheduled on the drawings.

E. Compressors: Provide serviceable, semi-hermetic, or fully hermetic compressors, complete with integral vibration isolators and crankcase heaters which de-energize during compressor operation.

1. Units shall have the following capacity control measures to prevent excessive compressor short cycling and prevent evaporator coil from freezing:
   a. Digital or Inverter scroll compressor as the first stage.

F. Evaporator Fans: Provide forward-curved, centrifugal, belt-driven fans with adjustable sheaves or direct-driven fans; and permanently lubricated motor bearings.

G. Condenser Fans: Provide propeller-type, direct-driven fans with permanently lubricated bearings.

H. Motors: Refer to Section "Common Motor Requirements for HVAC Equipment" for requirements.

I. Coils:

1. General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.
2. Refrigerant cooling coils: Refrigerant coils shall have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant. Coils shall be designed for 300 psig working pressure and pressure tested at 450 psig., then cleaned, dehydrated, and sealed with a holding charge of refrigerant. Provide 1 inch factory installed flexible elastomeric insulation around the suction and liquid lines not directly located above a condensate drain pan. If any piping is exposed to sunlight, provide UV protective coating.
3. Hot Gas Reheat Coil: Provide hot gas reheat coil with staged or modulating control for reheat during dehumidification operation. Hot gas reheat coil shall maintain space temperature when unit is operating in the dehumidification mode. Refer to sequence of operations.

J. Condensate Drain Pan: Provide galvanized or stainless steel condensate drain pan sloped to drain connection.

K. Heat Exchangers: Provide manufacturer's standard construction for gas-fired heat exchangers and burners. Minimum efficiency for heat exchangers shall be 80 percent.

1. Controls: Provide the following controls for the gas-fired heat exchangers:

a. Redundant gas valve;
b. Intermittent pilot ignition;
c. Electronic spark ignition system;
d. High limit cutout;
e. Forced draft proving switch.

L. Pre-Filter Section: Provide 2" thick fiberglass throwaway pleated filters in filter rack, with maximum face velocity of 400 fpm and minimum MERV rating per ASHRAE 52.2 of MERV 13.

M. Energy Recovery Section: Provide a factory mounted, wired, and tested energy recovery static core. The energy recovery corel shall have latent and sensible recovery capacities as required to meet or exceed the capacities scheduled on the drawings.
1. Provide a forward curved exhaust fan(s) with adjustable V-belt drive and a backdraft damper.
2. Provide a filter bank on the upstream side of each air stream with 2" thick fiberglass throwaway filters in filter rack, with maximum face velocity of 400 fpm and minimum MERV rating per ASHRAE 52.2 of MERV 13.
3. Bypass Dampers: Provide bypass dampers for economizer control. The energy recovery wheel shall be sized for the full airflow as scheduled.

N. Outdoor Air Intake Hood: Provide intake hood or louver designed to inhibit wind-driven rain and snow from entering unit. Provide complete with birdscreen, ½" mesh aluminum or stainless steel.

O. Dampers:

1. General: Dampers and their operators shall comply with performance requirements specified in Division 23 Section "Instrumentation and Control Devices for HVAC."

P. Outdoor Air Damper:

1. Provide outside air damper constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear.
2. Provide factory installed electric operator.

Q. Relief Control:

1. Power Exhaust Fan: Direct drive, propeller or backward inclined type designed for low tip speed. Motors shall be open drip-proof with internal motor protection and permanently lubricated ball bearings.

R. Variable Air Volume Control: Provide variable frequency drive to modulate fan to meet specified sequence of operation. Refer to Division 23 section "Variable Frequency Drives".

S. Safety Controls: Provide manual reset type safety controls for:

1. Low pressure cutout;
2. High pressure cutout;
3. Compressor motor overload protection.

T. Unit Controls: Solid-state control board and components contain at least the following features:

1. Indoor fan on/off delay.
2. Default control to ensure proper operation after power interruption.
3. Service relay output.
4. Unit diagnostics and diagnostic code storage.
5. Field-adjustable control parameters.
6. Dehumidification control with humidistat.
7. Gas valve delay between first- and second-stage firing.
8. Indoor-air quality control with carbon dioxide sensor.
9. Minimum run time.
10. Night setback mode.
11. Fan-proving switch to lock out unit if fan fails.
12. Dirty-filter switch.

U. Temperature Control: Provide remote sensor for field installation in supply air duct with sensor adjustment located in control panel. Provide space temperature sensor, wall mounted, with temperature adjustment in control panel.

V. Electrical: Provide a 125 VAC, 20 amp duplex convenience receptacle mounted to unit ready for field wiring through the curb with a cover UL listed for wet and damp locations when in use. Unit power connection shall be either through unit cabinet or within roof curb perimeter. Rooftop units shall be designed to meet a minimum short-circuit withstand rating as specified on the drawings.

W. Refrigerant Type: Provide units designed to operate with R-410 refrigerant.

X. Accessories: Units shall include the following accessories:

1. Provide guards to protect the condenser coil from hail or other damage.
2. Provide remote control panel containing control for fan, heating, cooling, and indicator lights.
3. Provide anti-recycling compressor control.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which dedicated outdoor air units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF ROOFTOP HEATING AND COOLING UNITS

A. General: Install dedicated outdoor air units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support:

1. Support roof-mounted units on roof curb. Attach roof curb to roof structure.
2. Support floor or on-grade units on cast-in-place concrete equipment bases.

C. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

D. Ductwork: Refer to Division-23 section "Metal Ducts". Connect supply and return ducts to unit with flexible duct connections. Provide transitions to exactly match unit duct connection size.

E. Piping: Piping installation requirements are specified in other Division 23 sections. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:

1. Condensate Drain Piping: Route condensate drain to nearest roof drain or to location shown on the drawings. Provide trap at connection to drain pan with depth as noted on the drawings and install cleanouts at changes in direction (refer to manufacturer's recommendations for any additional requirements). Size condensate drain piping in accordance with local code and as shown on the drawings.

3.3 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust fan for required airflow in accordance with Section "Testing, Adjusting and Balancing for HVAC." Tighten belts as required for proper operation.

B. Adjust damper linkages for proper damper operation.

C. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, intake plenum cabinet, heat exchange surfaces, cooling/heating coil sections, filter sections, access sections, etc.

3.4 STARTUP

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping, blocking, and bracing.
2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Comb coil fins for parallel orientation.
7. Install clean filters. Do not operate air handling unit without pre-filters installed.
8. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.
9. Disable automatic temperature control operators.

B. Start-Up Services: Provide the services of a factory-authorized service representative to start-up dedicated outdoor air units in accordance with manufacturer's written start-up instructions. Do not operate units without filters installed. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

1. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

a. Replace fan and motor pulleys as required to achieve design conditions.
b. Measure and record motor electrical values for voltage and amperage.
c. Shut unit down and reconnect automatic temperature control operators.
d. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for system testing, adjusting, and balancing.

3.5 TRAINING

A. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of two hours on the operation and maintenance of the equipment provided under this section.

B. Content: Training shall include but not be limited to:

1. Overview of the system and/or equipment as it relates to the facility as a whole.
2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

SECTION 238126 - SPLIT SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1. Indoor evaporator fan coil units.
2. Outdoor condenser units.

1.2 RELATED REQUIREMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division1 Specification Sections apply to this Section.

B. Section 221300 - Plumbing Piping for condensate drains.

C. Section 230500 – Common Work Results for HVAC for concrete, reinforcement, and formwork requirements.

D. Section 230529 – Hangers and Supports for HVAC Piping and Equipment.

E. Section 230550 – Vibration Isolation for HVAC Piping and Equipment.

F. Section 230593 - Testing, Adjusting, and Balancing for HVAC for unit balancing.

G. Section 230913 - Instrumentation and Control Devices for HVAC: Thermostats, humidistats, timeclocks.

H. Section 230923 – Direct Digital Control for HVAC for installing external control components.

I. Section 232300 – Refrigerant Piping for refrigerant piping connecting the system.

J. Section 233113 – Metal Ducts for ductwork connecting to units.

K. Section 262717 – Equipment Wiring: Electrical characteristics and wiring connections.

L. Section 233300 – Air Duct Accessories.

1.3 REFERENCE STANDARDS

A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; most current edition.

B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; most current edition.

C. NFPA 70 – National Electric Code.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, type of refrigerant used, refrigerant pipe sizing, and electrical characteristics. Provide short circuit current rating of units with factory mounted starter or variable frequency drive.

B. Shop Drawings: Provide drawings that indicate size, profile, dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

C. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

D. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, accessories, and trouble-shooting guide.

1. Include manufacturer's recommended maintenance schedule of units installed in a seacoast application, within 5 miles of the coast.

E. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

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

C. Units shall be designed to operate with HCFC-free refrigerants.

D. Units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 and bear the Listed Mark.

E. The system components shall be rated in accordance with AHRI Standard 210/240, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.

1.6 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations with roof construction and actual equipment provided. Roof specialties are specified in Division 7 Sections. Concrete, reinforcement and formwork are specified in Division 3 Sections.

1.7 WARRANTY

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

B. Special Warranty: A written warranty, executed by the manufacturer and signed by the Contractor, agreeing to replace components that fail in materials or workmanship within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed.

1. Warranty Period, Compressors: Manufacturers standard, but not less than 5 years after date of Substantial Completion.

1.8 SPARE PARTS

A. General: Furnish to Owner, with receipt, the following spare parts described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
1. One set of spare filters of each type required for each unit.

2. If HVAC equipment is used during the construction period, Contractor shall provide one set of filters (if system is designed to include pre-filters and after-filters, provide only pre-filters) when the unit is started and replace filters when needed, but not less than every month. On the day of substantial completion, the Contractor shall clean the unit and provide a new set of filters at each location in the unit.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier.
2. Daikin US Corporation.
3. Fujitsu.
4. Lennox Industries, Inc..
5. Mitsubishi Electric & Electronics USA, Inc.
6. Samsung.
7. York.

2.2 INDOOR UNITS

A. General: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.

B. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.

C. Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.

D. Motor: Comply with NEMA designation temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

E. Air Filters: Washable type for wall-mount units, minimum 1 inch thick throwaway type for all other units, unless scheduled otherwise.

F. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.

G. Controls: Unit-mounted panel with contactors, control transformer with circuit breaker, solid-state temperature- and humidity-control modules, time-delay relay, and thermostat.

H. Where scheduled on the drawings, provide condensate lift pump with a built-in safety cutoff switch and integral check valve on discharge.

2.3 OUTDOOR UNITS

A. General: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.

B. Air-Cooled Condenser:

1. General: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
2. Casing: Steel, baked enamel finish, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
3. Compressor: Hermetic scroll-type with resilient suspension system, oil strainer, crankcase heater, start capacitor, relay, contactor, and internal motor overload protection.
4. Accessories:

    a. Liquid line filter drier.
    b. High pressure switch (manual reset).
    c. Low pressure switch (automatic reset).
    d. Service valve with gauge ports.
    e. Thermometer well in liquid line.
    f. Low-ambient kit where scheduled.
    g. Compressor short-cycling controls.
    h. Reversing valve for heat pump units.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine area for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Verify that flooring or ceiling system is ready to receive work and opening dimensions are as indicated on Shop Drawings.

C. Verify that power supply is available and of the correct characteristics.

3.2 INSTALLATION

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

B. Install unit level and plumb.

C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

D. Install roof-mounted, compressor-condenser components on roof equipment supports with vibration isolation. Anchor units to supports with removable, cadmium-plated fasteners.

E. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base or polyethylene mounting base with vibration isolators.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping. The following are specific connection requirements:

1. Arrange piping installations adjacent to units to allow unit servicing and maintenance.
2. Connect piping to air-handling units with flexible connectors.
3. Connect water supply piping to the air leaving side of water coils.

4. Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Route unit condensate drain to location shown on the drawings or, if not shown, to nearest indirect waste connection. Provide trap at connection to drain pan with depth as noted on the drawings install cleanouts at changes in direction. Size condensate drain piping in accordance with local code and as shown on the drawings.

D. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect ductwork to units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories." Provide transitions to exactly match unit duct connection size.

3.4 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust fan for required airflow in accordance with Section "Testing, Adjusting and Balancing." Tighten belts as required for proper operation.

B. Adjust water coil flow, with control valves to full coil flow, to indicated gpm.

C. Adjust damper linkages for proper damper operation.

D. Set initial temperature and humidity set points.

E. Clean the entire unit including cabinet interiors just prior to substantial completion to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, intake plenum cabinet, heat exchange surfaces, cooling/heating coil sections, filter sections, access sections, etc.

3.5 STARTUP

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping, blocking, and bracing.
2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects. Verify vibration isolation and flexible connections are installed correctly.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set outside-air and return-air mixing dampers to minimum outside-air setting.
7. Comb coil fins for parallel orientation.
8. Install new filters at completion of installation and prior to testing, adjusting, and balancing. Do not operate air handling unit without pre-filters installed.
9. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.
10. Disable automatic temperature control operators.

B. Start-Up Services: Start-up units in accordance with manufacturer's written start-up instructions. Do not operate units without filters installed. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

1. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

    a. Replace fan and motor pulleys as required to achieve design conditions.
    b. Measure and record motor electrical values for voltage and amperage.
    c. Shut unit down and reconnect automatic temperature control operators.
    d. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for procedures for system testing, adjusting, and balancing.

3.6 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.7 DEMONSTRATION

1. General: At a time mutually agreed upon between the Owner and Contractor, provide the services of a factory trained and authorized representative to train Owner's designated personnel for a minimum of two hours on the operation and maintenance of the equipment provided under this section.
2. Content: Training shall include but not be limited to:

    a. Overview of the system and/or equipment as it relates to the facility as a whole.
    b. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
    c. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operating and Maintenance Data."

3. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.
4. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION 238126

SECTION 260010 - GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and to all following sections within Division 26.

1.2 SECTION INCLUDES

A. This Division requires providing complete functioning systems, and each element thereof, as specified, indicated, or reasonably inferred, on the Drawings and in these Specifications, including every article, device, or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the Work include, but are not limited to, materials, labor, supervision, supplies, tools, equipment, transportation and utilities.

B. Division 26 of these Specifications, and Drawings numbered with prefixes E, generally describe these systems, but the scope of the electrical work includes all such work indicated in all of the Contract Documents, including, but not limited to: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.

C. Drawings are graphic representations of the Work upon which the Contract is based. They show the materials and their relationship to one another, including sizes, shapes, locations, and connections. They also convey the scope of work, indicating the intended general arrangement of the equipment, fixtures, outlets and circuits without showing all of the exact details as to elevations, offsets, control lines, and other installation requirements. Use the Drawings as a guide when laying out the Work and to verify that materials and equipment will fit into the designated spaces, and which, when installed per manufacturers' requirements, will ensure a complete, coordinated, satisfactory and properly operating system.

D. Specifications define the qualitative requirements for products, materials, and workmanship upon which the Contract is based.

1.3 DEFINITIONS

A. Whenever used in these Specifications or Drawings, the following terms shall have the indicated meanings:

1. Furnish: "To supply and deliver to the project site, ready for unloading, unpacking, assembling, installing, and similar operations."
2. Install: "To perform all operations at the project site, including, but not limited to, and as required: unloading, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, testing, commissioning, starting up and similar operations, complete, and ready for the intended use."
3. Provide: "To furnish and install complete, and ready for the intended use."

4. Furnished by Owner (or Owner-Furnished) or Furnished by Others: "An item furnished by the Owner or under other Divisions or Contracts, and installed under the requirements of this Division, complete, and ready for the intended use, including all items and services incidental to the Work necessary for proper installation and operation. Include the installation under the warranty required by this Division.
5. Engineer: Where referenced in this Division, "Engineer" is the Engineer of Record and the Design Professional for the Work under this Division.

    a. A Consultant to, and an authorized representative of, the Architect, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the "Architect".

6. Contract Administrator: Where referenced in this Division, "Contract Administrator" is the primary liaison between the Owner and the Contractor. Specifically, for this project this is the "Architect".
7. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.
8. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other NRTLs that are acceptable to the AHJ, and standards that meet the specified criteria.
9. Substitution: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor. Substitutions include Value Engineering proposals.

    a. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
    b. Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.

10. Value Engineering: A systematic method to improve the "value" of goods and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. The goal of VE is to achieve the desired function at the lowest overall cost consistent with required performance.
11. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified

B. When 'furnish', 'install', 'perform', or 'provide' is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of Contractor, "provide" is implied.

C. The terms "approved equal", "equivalent", or "equal" are used synonymously and shall mean "accepted by or acceptable to the Engineer as equivalent to the item or manufacturer specified". The term "approved" shall mean labeled, listed, or both, by an NRTL, and acceptable to the AHJ over this project.

D. Manufacturers: The listing of specific manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
3. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference, unless otherwise noted.

E. The following definitions apply to excavation operations:

1. Additional Excavation: Where excavation has reached indicated sub-grade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
2. Sub-base: as used in this section refers to the compacted soil layer used in pavement systems between the sub-grade and the pavement base course material.
3. Sub-grade: as used in this section refers to the compacted soil immediately below the slab or pavement system.
4. Unauthorized excavation consists of removal of materials beyond indicated sub-grade elevations or dimensions without specific direction from the Contract Administrator.

1.4 REFERENCE STANDARDS

A. Execute all work in accordance with, and comply at a minimum with, National Fire Protection Association (NFPA) codes, state and local building codes, and all other applicable codes and ordinances in force, governing the particular class of work involved, for performance, workmanship, equipment, and materials. Additionally, comply with rules and regulations of public utilities and municipal departments affected by connection of services. Where conflicts between various codes, ordinances, rules, and regulations exist, comply with the most stringent. Wherever requirements of these Specifications, Drawings, or both, exceed those of the above items, the requirements of these Specifications, Drawings, or both, shall govern. Code compliance, at a minimum, is mandatory. Construe nothing in these Construction Documents as permitting work not in compliance, at a minimum, with these codes. Bring all conflicts observed between codes, ordinances, rules, regulations and these documents to the Contract Administrator's and Engineer's attention in sufficient time, prior to the opening of bids, to prepare the Supplementary Drawings and Specifications Addenda required to resolve the conflict.

B. If the conflict is not reported timely, prior to the opening of bids, resolve the conflict and provide the installation in accordance with the governing codes and to the satisfaction of the Contract Administrator and Engineer, without additional compensation. Contractor will be held responsible for any violation of the law.

C. Obtain timely inspections by the constituted authorities having jurisdiction; and, upon final completion of the Work, obtain and deliver to the Owner executed final certificates of acceptance from these authorities having jurisdiction.

D. All material, manufacturing methods, handling, dimensions, methods of installation, and test procedures shall conform to industry standards, acts, and codes, including, but not limited to the following, except where these Drawings and Specifications exceed them:

IBC	International Building Code
ADA	Americans with Disabilities Act
AEIC	Association of Edison Illuminating Companies
ANSI	American National Standards Institute
ASTM	American Society of Testing Materials

AWS	American Welding Society
AWWA	American Water Works Association
ICEA	Insulated Conductors Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
NBFU	National Board of Fire Underwriters
NEC	National Electrical Code, NFPA 70
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufactures' Association
NETA	InterNational Electrical Testing Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
UL	Underwriter's Laboratories

E. Comply with rules and regulations of public utilities and municipal departments affected by connections of services.

F. Perform all electrical work in compliance with applicable safety regulations, including OSHA regulations. All safety lights, guards, and warning signs required for the performance of the electrical work shall be provided by the Contractor.

G. Obtain and pay for all permits, licenses and fees that are required by the governing authorities for the performance of the electrical work.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordinate with other divisions for electrical work included in them but not listed in Division 26 or indicated on electrical Drawings.

B. Visit the site and ascertain the conditions to be encountered in installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make due provisions for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, and incorrect or faulty installation of any of the Work under this Division or for additional compensation for any work covered by this Division.

C. Refer to Drawings and divisions of the other trades and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. Make all offsets required to clear equipment, beams and other structural members, and to facilitate concealing conduit in the manner anticipated in the design.

D. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.

E. Provide materials with trim that will fit properly the types of ceiling, wall, or floor finishes installed.

F. Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste.

G. Maintain an electrical foreman on the jobsite at all times to coordinate this work with other trades so that various components of the electrical systems is installed at the proper time, fits the available space, and allows proper service access to all equipment. Carry on the Work in such a

manner that the Work of the other trades will not be handicapped, hindered, or delayed at any time.

H. Work of this Division shall progress according to the "Construction Schedule" as described in Division 01 and as approved by the Contract Administrator. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule so as to ensure successful achievement of all schedule dates.

I. Measurements and Layouts: The Drawings are schematic in nature but show the various components of the systems approximately to scale and attempt to indicate how they are to be integrated with other parts of the Work. Figured dimensions take precedence to scaled dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing all Contract Documents. Correct, at no additional costs to the Owner, errors that could have been avoided by proper checking and inspection.

1.6 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to the requirements of individual Sections. Additionally, prepare coordination drawings as required scope of installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one trade.

1. Information shall be project specific and drawn accurately to a scale large enough to resolve conflicts. Do not base coordination drawings on standard dimensional data.
2. Prepare floorplans, sections, elevations, and details as needed to adequately describe relationship of various systems and components.
3. Clearly indicate functional and spatial relationships of components of all systems specified in the Contract Documents, including but not limited to: architectural, structural, civil, mechanical, electrical, fire protection, and specialty systems.
4. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
5. Show location and size of access doors required for access to concealed equipment, fittings, controls, terminations, and cabling.
6. Indicate required installation sequence to minimize conflicts between entities.
7. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Contract Administrator indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
8. The details of the coordination are the responsibility of the Contractor and, where indicated on the Drawings, minor adjustments in raceway routing, device placement, device type, or equipment arrangement are not to be considered changes to the Contract.

B. Equipment Room Coordination Drawings: In accordance with the submittal procedures outlined within these Specifications, provide dimensioned layouts of electrical equipment locations within electrical rooms/closets, mechanical rooms, generator rooms, and fire pump rooms with equipment drawn to scale and identified therein.

1. Clearly identify all required working clearances and access provisions required for installation and maintenance.
2. Equipment layouts should be arranged accounting for considerations for required door openings and the clearances required by the equipment manufacturer.

3. Indicate path to allow for the future removal of each large piece of equipment (up to and including generators and unit sub-station transformers) without removal of non-related equipment or architectural elements.
4. Include work provided by others routed through the equipment rooms.

C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:

1. File Preparation Format: Same digital data software program, version, and operating system as original Drawings.
2. BIM File Incorporation: Develop and incorporate coordination drawing files into Building Information Model established for Project.

    a. Perform three-dimensional component conflict analysis as part of preparation of coordination drawings. Resolve component conflicts prior to submittal. Indicate where conflict resolution requires modification of design requirements by Contract Administrator.

3. Where Henderson Engineer's digital data files are provided to the Contractor for use in preparing coordination digital data files, Henderson Engineers makes no representations as to the accuracy or completeness of digital data files as they relate to the Drawings or Specifications.
4. Submit coordination drawings in accordance with the submittal procedures outlined within these Specifications.

1.7 SUBMITTALS

A. Refer to Division 01 and General Conditions for submittal requirements in addition to requirements specified herein.

B. Refer to Division 01 for acceptance of electronic submittals. If not specified by Division 01, provide electronic submittals. If Division 01 requires paper submittals, provide the quantity of submittals required, but no fewer than seven (7) sets.

C. For electronic submittals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Architect and Engineer that the submittals have been posted. If electronic submittal procedures are not defined in Division 01, Contractor shall include the website, username and password information needed to access the submittals. For submittals sent by e-mail, Contractor shall copy the Architect and Engineer's designated representatives. Contractor shall allow for the Engineer Review Time as specified. Contractor shall submit only the documents required to purchase the materials and/or equipment in the submittal.

D. Engineer Review Time: Transmit submittals as early as required to support the project schedule. Allow two weeks for Engineer review time, plus to/from mailing time via the Architect, plus a duplication of this time for resubmittal if required. Transmit submittals as soon as possible after Notice to Proceed and before Mechanical construction starts.

E. Submittals and shop drawings shall not contain the firm name, logo, seal, or signature of the Engineer. They shall not be copies of the work product of the Engineer. If the Contractor desires to use elements of such product, the license agreement for transfer of information obtained from the Engineer must be used.

F. Assemble and submit for review manufacturer product literature for material and equipment to be furnished and/or installed under this Division. Literature shall include shop drawings, manufacturer product data, performance sheets, samples, and other submittals required by this Division as noted in each individual Section. General product catalog data not specifically noted to be part of the specified product will be rejected and returned without review.

G. Separate submittals according to individual specification sections. Only resubmit those sections requested for resubmittal.

H. Provide submittals in sufficient detail so as to demonstrate compliance with these Contract Documents and the design concept. Highlight, mark, list or indicate the materials, performance criteria and accessories that are being proposed. Illegible submittals will be rejected and returned without review.

I. Refer to individual Sections for additional submittal requirements.

J. Before transmitting submittals and material lists, verify that the equipment submitted is mutually compatible with and suitable for the intended use. Verify that the equipment will fit the available space and maintain manufacturer recommended service clearances. If the size of equipment furnished makes necessary any change in location, or configuration, submit a shop drawing showing the proposed layout.

K. Submittals shall contain the following information:

1. The project name.
2. The applicable specification section and paragraph.
3. Equipment identification acronym as used on the drawings.
4. The submittal date.
5. The Contractor's stamp, which shall certify that the stamped drawings have been checked by the Contractor, comply with the Drawings and Specifications, and have been coordinated with other trades.
6. Submittals not so identified will be returned to the Contractor without action.

L. The checking and subsequent acceptance by the Engineer and/or Architect of submittals shall not relieve responsibility from the Contractor for (1) deviations from Drawings and Specifications; (2) errors in dimensions, details, sizes of equipment, or quantities; (3) omissions of components or fittings; and (4) not coordinating items with actual building conditions and adjacent work. Contractor shall request and secure written acceptance from the Engineer and Architect prior to implementing any deviation.

M. BIM Incorporation: Develop and incorporate Shop Drawing files into BIM established for Project.

1.8 SUBSTITUTIONS

A. Refer to Division 01 and General Conditions for substitutions in addition to requirements specified herein.

B. Materials, products, equipment, and systems described in the Bidding Documents establish a standard of required function, dimension, appearance and quality to be met by the proposed substitution.

C. The base bid shall include only the products from manufacturers specifically named in the drawings and specifications.

D. Request for Substitution:

1. Complete and send the Substitution Request Form attached at the end of this section for each material, product, equipment, or system that is proposed to be substituted.
2. The burden of proof of the merit of the proposed substitution is upon the proposer.
3. Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Contract Administrator, and Owner following:

    a. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
    b. Proposed substitution is consistent with the Contract Documents and will produce indicated results, including functional clearances, maintenance service, and sourcing of replacement parts.
    c. Proposed substitution has received necessary approvals of the Authorities Having Jurisdiction.
    d. Same warranty will be furnished for proposed substitution as for specified Work.
    e. If accepted substitution fails to perform as required, Contractor shall replace substitute material or system with that originally specified and bear costs incurred thereby.
    f. Coordination, installation and changes in the Work as necessary for accepted substitution will be complete in all respects.

E. Substitution Consideration:

1. No substitutions will be considered unless the Substitution Request Form is completed and attached with the appropriate substitution documentation.
2. Prior to receipt of Bids: No substitutions will be considered prior to receipt of bids unless written request for approval to bid has been received by the Engineer at least ten (10) calendar days prior to the date for receipt of bids.

    a. If the proposed substitution is approved prior to receipt of bids, such approval will be stated in an addendum. Bidders shall not rely upon approvals made in any other manner. Verbal approval will not be given.

3. After receipt of Bids: No substitutions will be considered after receipt of Bids and before award of the Contract.
4. After award of Contract: No substitutions will be considered after the Contract is awarded unless specifically provided in the Contract Documents.

1.9 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD format from the Engineer for a shipping and handling fee of $200 for a drawing set up to 12 sheets and $15 per sheet for each additional sheet.

B. Contractor shall request and complete the Electronic File Release Agreement form from the Engineer. Send the form along with a check made payable to Henderson Engineers, Inc. Contractor shall indicate the desired shipping method and drawing format on the attached form.

C. Contact the Contract Administrator for written authorization.

D. The following must be received before electronic drawing files will be sent:

1. Contract Administrator's written authorization

2. Engineer's release agreement form
3. Payment

1.10 QUALITY ASSURANCE

A. Execute all work under this Division in a thorough and professional manner by competent and experienced workmen duly trained to perform the work specified.

B. Install all work in strict conformance with all manufacturers' requirements and recommendations, unless these Documents exceed those requirements. Install all equipment and materials in a neat and professional manner, aligned, leveled, and adjusted for satisfactory operation, in accordance with NECA guidelines.

C. Unless indicated otherwise on the Drawings, provide all material and equipment new, of the best quality and design, free from defects and imperfections and with markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Provide all material and equipment of the same type from the same manufacturer whenever practicable.

D. Unless specified otherwise, manufactured items of the same types specified within this Division shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this Project.

1.11 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 and General Conditions for Operation and Maintenance Manuals in addition to requirements specified herein.

B. Submit manuals prior to requesting the final punch list and before all requests for Substantial Completion.

C. Instruct the Owner's permanent personnel in the proper operation of, startup and shutdown procedures and maintenance of the equipment and components of the systems installed under this Division.

D. Prior to Substantial Completion of the project, furnish to the Contract Administrator, for Engineer's review, and for the Owner's use, four (4) copies of Operation and Maintenance Manuals in labeled, hard-back three-ring binders, with cover, binding label, tabbed dividers and plastic insert folders for Record Drawings. Include local contacts, complete with address and telephone number, for equipment, apparatus, and system components furnished and installed under this Division of the specifications.

E. Each manual shall contain equipment data, approved submittals, shop drawings, diagrams, capacities, spare part numbers, manufacturer service and maintenance data, warranties and guarantees.

F. Refer to Division 01 for acceptance of electronic manuals for this project. For electronic manuals, Contractor shall submit the documents in accordance with this Section and the procedures specified in Division 01. Contractor shall notify the Contract Administrator and Engineer that the manuals have been posted. If electronic manual procedures are not defined in Division 01, Contractor shall include the website, username and password information needed to access the manuals. For manuals sent by e-mail, Contractor shall copy the Contract Administrator's and Engineer's designated representatives.

1.12 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections of this Division.

1.13 RECORD DRAWINGS

A. Refer to Division 01 and General Conditions for Record Drawings in addition to requirements specified herein.

B. A set of work prints of the Contract Documents shall be kept on the jobsite during construction for the purpose of noting changes. During the course of construction, the Contractor shall indicate on these Documents changes made from the original Contract Documents. Particular attention shall be paid to those items which need to be located for servicing. Underground utilities shall be located by dimension from column lines.

C. At the completion of the project, the Contractor shall obtain, at their expense, reproducible copies of the final drawings and incorporate changes noted on the jobsite work prints onto these drawings. These changes shall be done by a skilled drafter. Each sheet shall be marked "Record Drawing", along with the date. These drawings shall be delivered to the Contract Administrator.

1.14 DELIVERY, STORAGE AND HANDLING

A. Refer to Division 01 and General Conditions for Delivery, Storage and Handling in addition to requirements specified herein.

B. Deliver equipment and material to the job site in their original containers with labels intact, fully identified with manufacturer's name, make, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.

C. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and at all times, take every precaution to properly protect equipment and material from damage, including the erection of temporary shelters to adequately protect equipment and material stored at the Site. Equipment and/or material which becomes rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to the Contract Administrator.

D. Be responsible for the safe storage of tools, material and equipment.

1.15 WARRANTIES

A. Refer to Division 01 and General Conditions for Warranties in addition to requirements specified herein.

B. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.

C. Warrant each system and each element thereof against all defects due to faulty workmanship, design or material for a period of 12 months from date of Substantial Completion, unless specific

items are noted to carry a longer warranty in these Construction Documents or manufacturer's standard warranty exceeds 12 months. Remedy all defects, occurring within the warranty period(s), as stated in the General Conditions and Division 01.

D. Also warrant the following additional items:

1. All raceways are free from obstructions, holes, crushing, or breaks of any nature.
2. All raceway seals are effective.
3. The entire electrical system is free from all short circuits and unwanted open circuits and grounds.

E. The above warranties shall include labor and material. Make repairs or replacements without any additional costs to the Owner.

F. Perform the remedial work promptly, upon written notice from the Contract Administrator or Owner.

G. At the time of Substantial Completion, deliver to the Owner all warranties, in writing and properly executed, including term limits for warranties extending beyond the one year period, each warranty instrument being addressed to the Owner and stating the commencement date and term.

1.16 TEMPORARY FACILITIES

A. Refer to Division 01 and General Conditions for Temporary Facilities requirements in addition to requirements specified herein.

B. Temporary Utilities: The types of services required include, but are not limited to, electricity, telephone, and internet. When connecting to existing franchised utilities for required services, comply with service companies' recommendations on materials and methods, or engage service companies to install services. Locate and relocate services (as necessary) to minimize interference with construction operations.

C. Construction Facilities: Provide facilities reasonably required to perform construction operations properly and adequately.

1. Enclosures: When temporary enclosures are required to ensure adequate workmanship, weather protection and ambient conditions required for the work, provide fire-retardant treated lumber and plywood; provide tarpaulins with UL label and flame spread of 15 or less; provide translucent type (nylon reinforced polyethylene) where daylighting of enclosed space would be beneficial for workmanship, and reduce use of temporary lighting.
2. Heating: Provide heat, as necessary, to protect work, materials and equipment from damage due to dampness and cold. In areas where building is occupied, maintain a temperature not less than 65 degrees F. Use steam, hot water, or gas from piped distribution system where available. Where steam, hot water or piped gas are not available, heat with self-contained LP gas or fuel oil heaters, bearing UL, FM or other approval labels appropriate for application. Use electric-resistance space heaters only where no other, more energy-efficient, type of heater is available and allowable.

    a. Vent and exhaust fuel-burning heaters per SMACNA Guidelines for Source Control and equip units with individual-space thermostatic controls.
    b. If permanent HVAC systems are used during construction, provide HVAC Protection and replace all filtration prior to occupancy in accordance with SMACNA Guidelines.

1.17 FIELD CONDITIONS

A. Conditions Affecting Work In Existing Buildings: The following project conditions apply:

1. The Drawings describe the general nature of remodeling to the existing building; however, visit the site prior to submitting bid to determine the nature and extent of work involved.
2. Schedule work in the existing building with the Owner.
3. Perform certain demolition work prior to the remodeling. Perform the demolition that involves electrical systems, Light fixtures, equipment, raceways, equipment supports or foundations and materials.
4. Remove articles that are not required for the new work. Unless otherwise indicated, remove each item removed during this demolition from the premises and dispose in accordance with applicable federal, state and local regulations.
5. Finish material will be installed under other divisions.
6. Obtain permission from the Contract Administrator for roof penetrations and channeling of floors or walls not specifically noted on the Drawings.
7. Protect adjacent materials indicated to remain. For work specific to this Division, install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
8. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, provide temporary services for affected areas.

B. Conditions Affecting Excavations: The following project conditions apply:

1. Maintain and protect existing building services that transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.

C. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.

D. Use of explosives is not permitted.

E. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits specified by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

PART 2 - PRODUCTS AND MATERIALS

(Not Used)

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 EXISTING CONDITIONS

A. Existing conditions indicated on the Drawings are taken from the best information available from the Owner, existing record drawings, and from limited, in-situ, visual site observations; and, they are not to be construed as "AS BUILT" conditions. The information is shown to help establish the extent of the new work.

B. Verify all actual existing conditions at the project site and perform the Work as required to meet the existing conditions and the intent of the Work indicated.

C. Notify Contract Administrator immediately of any dangerous conditions that exist on the job site, as they are discovered, before demolition, during selective demolition or before remodel work begins.

3.3 EXISTING UTILITIES

A. Prepare and submit a schedule of anticipated utility outages indicating dates and duration. Schedule

B. Schedule and coordinate with the utility companies, Owner and with the Contract Administrator all connections to, relocation of, or discontinuation of normal utility services from any existing utility line. Include all premium time required for all such work in the bid.

C. Repair all existing utilities damaged due to construction operations to the satisfaction of the Owner or utility companies without additional cost.

D. Do not leave utilities disconnected at the end of a workday or over a weekend unless authorized by representatives of the Owner or Contract Administrator.

E. Make repairs and restoration of utilities before workers leave the project at the end of the workday in which the interruption takes place.

F. Include in bid the cost of furnishing temporary facilities to provide all services during interruption of normal utility service.

3.4 WORK IN EXISTING FACILITIES

A. The Drawings describe the general nature of remodeling to the existing facilities; however, visit the site prior to submitting a bid, to determine the nature and extent of work involved.

B. Schedule work in the existing facility with the Owner.

C. Certain demolition work shall be performed prior to the remodeling. Perform the demolition that involves electrical systems, fixtures, conduit, wiring, equipment, equipment supports or foundations and materials.

D. Remove all of these articles that are not required for the new work. Unless otherwise indicated, each item removed during this demolition shall be removed from the premises and disposed of in accordance with all state and local regulations.

E. 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 Contract Administrator and the Owner no fewer than 7 days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Contract Administrator and the Owner's written permission.
3. Owner reserves the right to require Contractor to cease work in any area Owner requires access to on an emergency basis.
4. Make every effort to schedule outages during non-business or off-peak business hours to minimize disruptions to business operations.

F. Relocate and reconnect all electrical facilities that must be relocated in order to accomplish the remodeling shown in the Drawings or indicated in the Specifications. Where electrical fixtures or equipment are removed, cap all unused raceways behind the floor line or wall line to facilitate restoration of finish, and, remove all existing wiring from abandoned raceways.

G. Finish materials are specified in other divisions.

H. Where removal of existing wiring interrupts electrical continuity of circuits that are to remain in use, provide necessary wiring, raceways, junction boxes, etc., to ensure continued electrical continuity.

I. Penetrate roofs, channel walls and floors as required to produce the desired result; however, obtain permission from the Contract Administrator for all penetrations and channeling not specifically noted on the Drawings.

J. Provide new, typewritten card directory for distribution equipment (including but not limited to load centers, panelboards, switchboards and switchgear) where changes occur under this scope of work. Indicate exact loads served by each existing circuit breaker or switch. Where circuit designations are not specifically indicated on the Drawings, provide a unique identifier for each updated circuit within the directory.

K. Coordinate work with Architectural phasing drawings to properly stage transitions of work to provide power to existing, new and temporary loads. Monitor loads on distribution system to ensure shifting of loads does not overload electrical equipment.

3.5 PERMITS

A. Secure and pay for all permits required in connection with the installation of the Electrical Work. Arrange with the various utility companies for the installation and connection of all required utilities for this facility and pay all charges associated therewith including connection charges and inspection fees, except where these services or fees are designated to be provided by others.

3.6 TEMPORARY ELECTRICAL SERVICE AND WIRING

A. Provide 208Y/120 volt, three-phase, four-wire, temporary electrical service and temporary lighting system to facilitate construction.

B. In existing facilities, with Owner's approval, Contractor may utilize the existing electrical system as the source of temporary power. Coordinate the point of connection and method of connection to the existing system with the Owner's Representative.

C. Pay all charges made by the Electric Utility, with respect to installation and energy charges for temporary services.

D. Work for the temporary power shall consist of all labor and materials, including, but not limited to conduit, wiring, panelboards, fuse blocks, fused disconnecting switches, fuses, pigtails, receptacles, wood panel switch supports, and other miscellaneous materials required to complete the power system.

E. Install all temporary wiring in accordance with applicable codes, and maintain in an OSHA-approved manner.

F. Provide an adequate number of GFCI type power distribution centers, rated 208Y/120V, four-wire, and not less than 60A, with sufficient fuse blocks or breakers for lighting and hand tool circuits, 60A four-wire feeders, all mounted within pre-fabricated enclosures UL listed for this application or on suitable wood panels bolted to columns or upright wood supports as required.

G. Install circuits to points on each level of each building so that service outlets can be reached by a 50-foot extension cord for 120V power and a 100-foot extension cord for 208V power (or as required by OSHA or local authorities).

H. Provide one lighting outlet per 30 linear feet of corridor and at least one light in each room and for every 800 square feet of floor area. Temporary lighting shall comply with OSHA requirements.

I. If additional service is required for cranes, electrical welders or for electric motors over 1/2 HP per unit, such additional service shall become the responsibility of the trade involved.

J. When the permanent wiring for lighting and power is installed, with approval of the Contract Administrator and Owner, the permanent system may be used, provided the Contractor assumes full responsibility for all electrical material, equipment, and devices contained in the systems and provided that roof drainage system and roofing are complete.

K. When directed by the Contract Administrator, remove all temporary services, lighting, wiring and devices from the property.

3.7 SELECTIVE DEMOLITION

A. Refer to Division 01, Division 02, and General Conditions for Selective Demolition requirements in addition to the requirements specified herein.

B. General: Demolish, remove, demount, and disconnect abandoned electrical materials and equipment indicated to be removed and not indicated to be salvaged or saved.

C. Materials and Equipment To Be Salvaged: remove, demount, disconnect existing electrical materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.

D. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.

E. Electrical Materials and Equipment: Demolish, remove, demount, and disconnect the following items:

1. Inactive and obsolete raceways, fittings, supports and specialties, equipment, wiring, controls, fixtures, and insulation:

a. Raceways and outlets embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Cut embedded raceways to below finished surfaces, seal, and refinish surfaces as specified or as indicated on the Architectural Finish Drawings. Remove materials above accessible ceilings. Cap raceways allowed to remain.
b. Perform cutting and patching required for demolition in accordance with Division 01, General Conditions and "Cutting and Patching" portion of this Section in Division 26.

3.8 ACCESS TO EQUIPMENT

A. Locate all pull boxes, junction boxes and controls to provide easy access for operation, service inspection and maintenance. Provide an access door where equipment or devices are located above inaccessible ceilings. Refer to Division 26 Section "Common Work Results for Electrical".

B. Maintain all code required clearances and clearances required by manufacturers.

3.9 PENETRATIONS

A. Unless otherwise noted as being provided under other divisions, provide sleeves, box frames, or both, for openings in floors, walls, partitions and ceilings for all electrical work that passes through construction. Refer to Division 26 Section "Common Work Results for Electrical".

B. Provide sleeves, box frames, or both, for all conduit, cable, and busways that pass through masonry, concrete or block walls.

C. The cutting of new and/or existing construction will not be permitted except by written approval of the Contract Administrator.

3.10 EXCAVATION AND BACKFILLING

A. Refer to Division 01, Division 02 and General Conditions for Excavation and Backfilling in addition to the requirements specified herein.

B. Perform excavation of every description, of whatever substance encountered and to the depth required in connection with the installation of the work under this division. Excavation shall be in conformance with applicable Divisions and sections of the Specifications.

C. Restore roads, alleys, streets and sidewalks damaged during this work to the satisfaction of Authorities Having Jurisdiction.

D. Do not excavate trenches close to walks or columns without prior consultation with the Contract Administrator.

E. Erect barricades around excavations, for safety, and place an adequate number of amber lights on or near the work and keep those burning from dusk to dawn. Be responsible for all damage that any parties may sustain in consequence of neglecting the necessary precautions in prosecuting the work.

F. Slope sides of excavations to comply with local, state, and federal codes and ordinances. Shore and brace as required for stability of excavation.

G. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local, state, and federal codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.

H. Install sediment and erosion control measures in accordance with local codes and ordinances.

I. Dewatering: Prevent surface water and subsurface or ground water 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 bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches. In no case shall sewers be used as drains for such water.

J. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

K. Trenching: Excavate trenches for electrical installations as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of six to nine inches clearance on both sides of raceway and cables.
2. Excavate trenches to depth indicated or required for raceway and cables to establish slope, away from buildings and indicated elevations. Beyond building perimeter, excavate trenches to an elevation below frost line.
3. Limit the length of open trench to that in which raceway and cables can be installed, tested, and the trench backfilled within the same day.
4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceway and cables. Provide a minimum of six inches of stone or gravel cushion between rock bearing surface and raceway and cables.
5. Excavate trenches for raceway, cables, and equipment with bottoms of trench to accurate elevations for support of raceway and cables on undisturbed soil.

L. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F.

M. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.

1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
2. Under building slabs, use drainage fill materials.
3. Under raceway and cables, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.

4. For raceway and cables less than 30 inches below surface of roadways, provide 4-inch-thick concrete base slab support. After installation and testing of raceway and cables, provide a 4-inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
5. Other areas use excavated or borrowed materials.

N. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval, and locations of underground utilities have been recorded.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids.
4. Removal of trash and debris.

O. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

1. For vertical and diagonal raceway installations, thoroughly support raceways from permanent structures or undisturbed earth at no less that 10-foot intervals, while placing backfill materials, so that raceways are not deflected, crushed, broken, or otherwise damaged by the backfill placement.

P. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

Q. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.

R. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below:

1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

    a. Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
    b. Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
    c. Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

2. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to

achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.

S. Subsidence: Where subsidence occurs at mechanical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

3.11 CUTTING AND PATCHING

A. Cut walls, floors, ceilings, and other portions of the facility as required to install work under this Division.

B. Obtain permission from the Architect prior to cutting. Do not cut or disturb structural members without prior approval from the Architect and Structural Engineer.

C. For post-tension slabs, x-ray slab and closely coordinate all core drill locations with Architect and Structural Engineer prior to performing any work. Obtain approval from Architect and Structural Engineer for all core drills and penetrations at least four days prior to performing work.

D. Penetrations shall be made as small as possible while maintaining required clearances between the building element penetrated and the system component.

E. Patch around openings to match adjacent construction, including fire ratings, if applicable.

F. Repair and refinish areas disturbed by work to the condition of adjoining surfaces in a manner satisfactory to the Architect.

3.12 PAINTING

A. Refer to Division 09 Section "Painting" for painting requirements.

B. Paint exposed ferrous surfaces, including, but not limited to, hangers, equipment stands and supports using materials and methods as specified under individual sections and Division 09 of the Specifications; colors shall be as selected by the Contract Administrator.

C. Re-finish all field-threaded ends of galvanized conduits and field-cut ends of galvanized supports with a cold-galvanizing compound approved for use on conductive surfaces. Follow closely manufacturer's instructions for pre-cleaning surfaces and application.

D. Factory finishes and shop priming and special finishes are specified in the individual equipment Specification sections.

E. Where factory finishes are provided and no additional field painting is specified, touch up or refinish, as required by, and to the acceptance of, the Contract Administrator, marred or damaged surfaces so as to leave a smooth, uniform finish. If, in the opinion of the Contract Administrator, the finish is too badly damaged to be properly re-finished, replace the damaged equipment or materials at no additional costs to the Owner.

3.13 CLEANING

A. Remove dirt and refuse, resulting from the performance of the Work, from the premises as required to prevent accumulation. Cooperate in maintaining reasonably clean premises at all times.

B. Immediately prior to the final inspection, the Electrical Contractor shall clean material and equipment installed under the Electrical Contract. Dirt, dust, plaster, stains, and foreign matter shall be removed from surfaces including components internal to equipment.

C. Damaged finishes shall be touched-up and restored to their original condition

3.14 ADJUSTING, ALIGNING AND TESTING

A. Adjust, align and test all electrical equipment furnished and/or installed under this Division.

B. Check motors for alignment with drive and proper rotation, and adjust as required.

C. Check and test protective devices for specified and required application, and adjust as required.

D. Check, test and adjust adjustable parts of all light fixtures and electrical equipment as required to produce the intended performance.

E. Verify that completed wiring system is free from short circuits, unintentional grounds, low insulation impedances, and unintentional open circuits.

F. After completion, perform tests for continuity, unwanted grounds, and insulation resistance in accordance with the requirements of NFPA 70 and NETA.

G. Be responsible for the operation, service and maintenance of all new electrical equipment during construction and prior to acceptance by the Owner of the complete project under this Contract. Maintain all electrical equipment in the best operating condition including proper lubrication.

H. Notify the Contract Administrator immediately of all operational failures caused by defective material, labor or both.

I. Maintain service and equipment for all testing of electrical equipment and systems until all work is approved and accepted by the Owner.

J. Keep a calibrated voltmeter and ammeter (true RMS type) available at all times. Provide service for test readings when and as required.

K. Refer to individual sections for additional and specific requirements.

3.15 START-UP OF SYSTEMS

A. Prior to start-up of electrical systems, check all components and devices, lubricate items appropriately, and tighten all screwed and bolted connections to manufacturers' recommended torque values using appropriate torque tools.

B. Each power, lighting and control circuit shall be energized, tested and proved free of breaks, short-circuits and unwanted grounds.

C. Adjust taps on each transformer for rated secondary voltages.

D. Balance all single phase loads at each panelboard, redistributing branch circuit connections until balance is achieved to plus or minus 10 percent.

E. After all systems have been inspected and adjusted, confirm all operating features required by the Drawings and Specifications and make final adjustments as necessary.

F. Demonstrate that all equipment and systems perform properly as designed per Drawings and Specifications.

G. At the time of final review and tests of the power and lighting systems, all equipment and system components shall be in place and all connections at panelboards, switches, circuit breakers, and the like, shall be complete. All fuses shall be in place, and all circuits shall be continuous from point of service connections to all switches, receptacles, outlets, and the like.

3.16 TEST REPORTS

A. Perform tests as required by these Specifications and submit the results to the Contract Administrator, for Engineer's review. Record the results, date and time of each test and the conditions under which the test was conducted. Include a copy of the finalized test results, with corrections made, in the operations and maintenance manuals. The tests shall establish the adequacy, quality, safety, and reliability for each electrical system installed. Notify the Contract Administrator and Engineer two working days prior to each test.

B. For specific testing requirements of special systems, refer to the Specification section that describes that system. The Contractor shall provide the following to facilitate the testing of the electrical systems:

1. Perform tests as described in the individual sections

C. Upon completing each test, record the results, date and time of each test and the conditions under which the test was conducted. Submit to the Contract Administrator, for Engineer's review, in duplicate, the test results for the following electrical items:

1. Building service entrance voltage and amperes at each phase.
2. Electrical service grounding conditions and grounding resistance.
3. Proper phasing throughout the entire system.
4. Voltages (phase-to-phase and phase-to-neutral) and amperes at each phase for each panelboard, switchboard, and the like.
5. Phase voltages and amperes at each three-phase motor.
6. Test all wiring devices for electrical continuity and proper polarity of connections.

D. Promptly correct all failures or deficiencies revealed by these tests in accordance with the manufacturer's recommendations and as determined by the Engineer.

3.17 SUBSTANTIAL COMPLETION REVIEW

A. Prior to requesting a site observation for "CERTIFICATION OF SUBSTANTIAL COMPLETION", complete the following items:

1. Submit complete Operation and Maintenance Data.
2. Submit complete Record Drawings.

3. Perform all required training of Owner's personnel.
4. Turn over all spares and extra materials to the Owner, along with a complete inventory of spares and extra materials being turned over.
5. Perform start-up tests of all systems.
6. Remove all temporary facilities from the site.
7. Comply with all requirements for Substantial Completion in the Division 01 and General Conditions.

B. Request in writing a review for Substantial Completion. Give the Contract Administrator at least seven (7) days notice prior to the review.

C. State in the written request that the Contractor has complied with the requirements for Substantial Completion.

D. Upon receipt of a request for review, the Contract Administrator will either proceed with the review or advise the Contractor of unfilled requirements.

E. If the Contractor requests a site visit for Substantial Completion review prior to completing the above-mentioned items, he shall reimburse the Contract Administrator and Engineer for time and expenses incurred for the visit.

F. Upon completion of the review, the Contract Administrator will prepare a "final list" of outstanding items to be completed or corrected for final acceptance.

G. Omissions on the "final list" shall not relieve the Contractor from the requirements of the Contract Documents.

H. Prior to requesting a final review, submit a copy of the final list of items to be completed or corrected. State in writing that each item has been completed, resolved for acceptance or the reason it has not been completed.

END OF SECTION

SUBSTITUTION REQUEST FORM

To Project Engineer: _____ Request # (GC Determined): _____

Project Name: _____

Project No/Phase: _____ Date: _____

Specification Title: _____

Section Number: _____ Page: _____ Article/Paragraph: _____

Proposed Substitution: _____

_____

Manufacturer: _____ Model No.: _____

Address: _____ Phone: _____

History: ☐ New product ☐ 1-4 years old ☐ 5-10 years old ☐ More than 10 years old

Differences between proposed substitution and specified Work: _____

_____

☐ Point-by-point comparative data attached – REQUIRED BY ENGINEER
Comparative data may include but not be limited to performance, certifications, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements. Include all information necessary for an evaluation.

Supporting Data Attached: ☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐ Other: _____

Reason for not providing specified item: _____

_____

Similar Installation:
Project: _____ Architect: _____

Address: _____ Owner: _____

_____ Date Installed: _____

Proposed substitution affects other parts of Work: ☐ No ☐ Yes; explain: _____

_____

_____

Substitution Certification Statement:

Unless stated otherwise in writing to the Engineer by the Contractor, Contractor warrants to the Engineer, Architect, and Owner that the:

A. Proposed substitution has been fully investigated and determined to meet or exceed the specified Work in all respects.
B. Proposed substitution is consistent with the Contract Documents and will produce indicated results.
C. Proposed substitution does not affect dimensions and functional clearances.
D. Proposed substitution has received necessary approvals of authorities having jurisdiction.
E. Same warranty will be furnished for proposed substitution as for specified Work.
F. Same maintenance service and source of replacement parts, as applicable, is available.
G. Proposed substitution will not adversely affect other trades or delay construction schedule.
H. Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitting Contractor	Date	Company

Manufacturer's Certification of Equal Quality:

I _____ represent the manufacturer of the Proposed Substitution item and hereby certify and warrant to Architect, Engineer, and Owner that the function and quality of the Proposed Substitution meets or exceeds the Specified Item.

Manufacturer's Representative	Date	Company

Engineer Review and Recommendation Section

Recommend Acceptance	☐ Yes	☐ No
Additional Comments:	☐ Attached	☐ None

Acceptance Section:

Contractor Acceptance Signature	Date	Company
Owner Acceptance Signature	Date	Company
Architect Acceptance Signature	Date	Company
Engineer Acceptance Signature	Date	Company

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes limited scope general construction materials and methods, electrical equipment coordination, and common electrical installation requirements as follows:

1. Access doors in walls, ceilings, and floors for access to electrical materials and equipment.
2. Sleeves and seals for electrical penetrations.
3. Joint sealers for sealing around electrical materials and equipment, and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
4. Sealing penetrations through noise critical spaces.

1.2 DEFINITIONS

A. The following abbreviations apply to this and other Sections of these Specifications:

1. AHJ: Authority(ies) having Jurisdiction
2. ATS: Acceptance Testing Specifications
3. EPDM: Ethylene-propylene-diene monomer rubber
4. MC: Metal Clad
5. N/A: Not Available or Not Applicable
6. NBR: Acrylonitrile-butadiene rubber
7. NRTL: Nationally Recognized Testing Laboratory
8. PCF: Pounds per Cubic Foot

B. The following definitions apply to this and other Sections of these Specifications:

1. Homerun: That portion of an electrical circuit originating at a junction box, termination box, receptacle or switch with termination at an electrical panelboard. Note: Where MC Cable is utilized for receptacle and/or lighting branch circuiting loads, the originating point of the homerun shall be at the first load in the circuit or at a junction box in an accessible ceiling space immediately above the first load.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping, ducts, and other systems installed at required slopes and/or elevations.
4. So connecting raceways, cables, and wireways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

D. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":

1. Product data for the following products:

    a. Sleeve seals.
    b. Through and membrane penetration firestopping systems.
    c. Joint sealers
    d. Acoustical sealers
    e. Endothermic wrap

2. Shop drawings for:

    a. Detailed fabrication drawings of access panels and doors.

3. Through and Membrane Penetration Firestopping Systems Product Schedule: Provide UL listing, location, wall or floor rating and installation drawing for each penetration fire stop system.

    a. Where Project conditions require modification to qualified testing and inspecting agency's illustrations for a particular firestopping condition, submit illustration, with modifications marked, approved by penetration firestopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.
    b. Qualifications data for testing agency.

4. Endothermic Wrap drawings and system details: Provide UL listing, assembly rating and installation drawing for each case specific installation. Include installation instructions indicating layers of wrap required and securing method.

    a. Where Project conditions require modifications to qualified testing and inspecting agency's installation requirements for a particular listed fire rated electrical circuit protective system, submit illustration with modifications marked and approved by Endothermic Wrap manufacturer's fire protection engineer as an engineering judgement or equivalent fire-resistive-rated assembly.

5. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26

    a. Accurately record actual locations of firestopped penetrations and access panel/door locations. Indicate dimensions from fixed structural elements.

PART 2 -

PART 2 - PRODUCTS AND MATERIALS

2.1 ACCESS TO EQUIPMENT

A. Manufacturers:

1. Bar-Co., Inc.
2. Elmdor Stoneman.
3. JL Industries
4. Jay R. Smith Mfg. Co.
5. Karp Associates, Inc.
6. Milcor
7. Nystrom Building Products
8. Wade
9. Zurn

B. Access Doors:

1. Provide access doors for all concealed equipment, except where above lay-in ceilings. Refer to Section "Identification for Electrical Systems" for labeling of access doors.
2. Access doors shall be adequately sized for the devices served with a minimum size of 18 inches x 18 inches, furnished by the respective Contractor or Subcontractor and installed by the General Contractor.
3. Access doors must be of the proper construction for type of construction where installed.
4. The exact location of all access doors shall be verified with the Contract Administrator prior to installation.
5. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
6. Frames: 16-gauge steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.

    a. For installation in masonry, concrete, ceramic tile, or wood paneling: 1-inch-wide exposed perimeter flange and adjustable metal masonry anchors.
    b. For installation in gypsum wallboard or plaster: perforated flanges with wallboard bead.
    c. For installation in full-bed plaster applications: galvanized, expanded metal lath and exposed casing bead, welded to perimeter of frame.

7. Flush Panel Doors: 14-gauge sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.
8. Locking Devices:

    a. Flush, screwdriver-operated cam locks.

2.2 SLEEVES

A. Steel sleeves for raceways and cables:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends and drip rings.

B. Cast iron wall pipe sleeves for raceways and cables:

1. Manufacturers

    a. Josam Mfg. Co.
    b. Smith (Jay R) Mfg. Co.
    c. Tyler Pipe/Wade Div.; Subs of Tyler Corp.
    d. Watts Industries, Inc.
    e. Zurn Industries, Inc.; Hydromechanics Div.

2. Cast-iron sleeve with integral clamping flange with clamping ring, and nuts for membrane flashing.

    a. Underdeck Clamp: Clamping ring with setscrews.

3. Sleeves for rectangular openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping to be used.

2.3 SEALANTS

A. SLEEVE SEALS

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
2. Manufacturers:

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Metraflex Co.
    d. O-Z/Gedney
    e. Pipeline Seal and Insulator, Inc.

3. Sealing Elements: Interlocking or solid sealing links shaped or pre-drilled to fit surface of cable or raceway. Include type and number required for material and size of raceway or cable.

    a. EPDM
    b. NBR
    c. Neoprene

4. Pressure Plates: Include two for each sealing element. For multi-phase circuits, use slotted pressure plates if metal.

    a. Plastic
    b. Carbon steel
    c. Stainless steel
    d. PVC-coated steel

5. Connecting Bolts and Nuts: Provide bolts of length required to secure pressure plates to sealing elements. Include one for each sealing element.

    a. Carbon steel with corrosion-resistant coating
    b. Stainless steel

B. JOINT SEALERS

1. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
2. Colors: As selected by the Contract Administrator from manufacturer's standard colors.
3. Elastomeric Joint Sealers: Provide the following types:

    a. Silicone Joint Sealants, One-part nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer. Provide one of the following:

        1) Dow Corning, Dowsil 790
        2) Dow Corning, Dowsil 795
        3) GE, Silglaze II SCS 2350
        4) GE, Silpruf SCS 2000
        5) Owens Corning, Energy Complete
        6) Pecora, 864 NST
        7) Tremco, Spectrem 1
        8) Tremco, Spectrem 2

    b. Mildew Resistant Sealants, one-part mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, metal or porcelain plumbing fixtures and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes. Provide one of the following:

        1) Dow Corning, Dowsil 786
        2) GE, Momentum SCS 1700
        3) Pecora, 898 Silicone NST

    c. Hybrid Joint Sealants: One-part, nonsag, paintable complying with ASTM C 920, Type S, Grade NS, Class 50 recommended for exposed applications on interior and exterior locations involving joint movement of not more than plus or minus 50 percent. Subject to compliance with requirements, provide one of the following:

        1) BASF, MasterSeal NP 100
        2) Pecora, DyanTrol I-XL
        3) Tremco, Dymonic FC

C. FIRESTOPPING

1. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with UL 2079 or ASTM E 814, by Underwriters' Laboratories, Inc., or other NRTL acceptable to AHJ. Subject to compliance with requirements, provide one of the following:

    a. Manufacturers:

        1) 3M Corp., Fire Barrier Sealant
        2) Hilti, Inc.
        3) Tremco, Tremstop Fyre-Sil
        4) Pecora, AC-20 FTR
        5) RectorSeal

6) Specified Technologies Inc. Firestop
7) USG, SHEETROCK Firecode Compound
8) Owens Corning Firestopping Insulation

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

C. Coordinate seals with wall, ceiling, roof or floor materials and rating of the surface (sound, fire, waterproofing, etc.)

D. Comply with NECA 1.

E. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless indicated otherwise.

F. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

G. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

H. Right of Way: Yield to raceways and piping systems installed at a required slope.

3.2 ACCESS DOORS

A. Verify the exact location, sizes, and types of all access doors with the Contract Administrator prior to purchase.

B. Provide access doors for all concealed electrical equipment, except where above lay-in ceilings.

C. Coordinate with architectural finishes to set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

D. Adjust hardware and panels after installation for proper operation.

E. Label all access doors with a nameplate as described in Division 26 Section "Identification for Electrical Systems".

3.3 SLEEVES AND SLEEVE SEALS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Provide sleeves for required openings in all concrete and masonry construction and fire, smoke, or both, partitions, for all electrical work that passes through such construction. Coordinate with all other trades and divisions to dimension and lay out all such openings.

C. Only those openings specifically indicated on the Architectural or Structural Drawings will be provided under other divisions.

D. New Construction:

1. Coordinate with Divisions 03 and 04 for installation of sleeves and sleeve seals integrally in cast-in-place, precast, and masonry walls and horizontal slabs where indicated on the Drawings or as required to support raceway penetrations.

E. Construction in Existing Facilities:

1. Saw cut or core drill existing walls, roofs and slabs to install sleeves and sleeve seals in existing facilities. Do not cut or drill any walls, roofs or slabs without first coordinating with, and receiving approval from, the Contract Administrator, Owner, or both. Seal sleeves into concrete walls or slabs with a waterproof non-shrink grout acceptable to the Contract Administrator. Provide roofing penetration seals and covers to match existing roofing materials. Coordinate roofing repair of adjacent roofing material with Owner's roofing contractor to provide a waterproof installation.

F. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls. Do not cut or core drill new construction without written approval from the Contract Administrator and Structural Engineer.

G. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

H. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

I. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

J. Install pipe and rectangular sleeves in above-grade walls and slabs, where penetrations are not subject to hydrostatic water pressures. Ensure that drip ring is fully encased and sealed within the wall or slab.

K. Sleeve Length:

1. Sleeves through walls: Cut sleeves to length for mounting flush with both surfaces of walls.

L. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed; in which case, size sleeves as recommended by the seal manufacturer.

M. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

N. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint

O. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials.

P. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

Q. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (or larger, if required by the seal manufacturer) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

R. Above Grade Concrete or Masonry Penetrations

1. Provide sleeves for cables or raceways passing through above grade concrete or masonry walls, concrete floor or roof slabs. Sleeves are not required for core drilled holes in existing masonry walls, concrete floors or roofs. Provide sleeves as follows:

    a. Install schedule 40 galvanized steel pipe for sleeves smaller than 6 inches in diameter.
    b. Install galvanized sheet metal for sleeves 6 inches in diameter and larger, thickness shall be 0.138 inches.
    c. Install galvanized sheet metal for rectangular sleeves
    d. Schedule 40 PVC pipe sleeves are acceptable for use in areas without return air plenums.

2. Seal elevated floor, exterior wall and roof penetrations watertight and weather tight with non-shrink, non-hardening commercial sealant. Pack with mineral wool and seal both ends with minimum of ½" of sealant.

S. Elevated Floor Penetrations of waterproof membrane:

1. Provide cast-iron wall pipes for sleeves. Size wall pipe for minimum ½" annular space between wall pipe and cable or raceway.
2. Pack with mineral wool and seal both ends with minimum of ½" of waterproof sealant.
3. Secure waterproof membrane flashing between clamping flange and clamping ring.
4. Extend bottom of wall pipe below floor slab as required and secure underdeck clamp to hold wall pipe rigidly in place.

T. Interior Foundation Penetration: Provide sleeves for horizontal raceway passing through or under foundation. Sleeves shall be cast iron soil pipe two normal pipe sizes larger than the pipe served.

U. Interior Penetrations of Non-Fire-Rated Walls: Seal annular space between sleeve and cable or raceway, using joint sealant appropriate for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of ½" of sealant.

V. Exterior Wall Penetrations: Seal annular space between sleeve and raceway or duct, using joint sealant for size, depth, and location of joint. Pack with mineral wool and seal both ends with minimum of ½" of waterproof sealant.

W. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

X. Sleeve-Seal Installation

1. Install sleeve seals for all underground raceway penetrations through walls at elevations below finished grade. Additionally, install seals inside raceways, after conductors or cables have been installed, in all raceway penetrations through walls at elevations below finished grade.
2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Y. Inspect installed sleeve and sleeve-seal installations for damage and faulty work. Verify watertight integrity of sleeves and seals installed below grade and above grade where installed to seal against hydrostatic pressure.

Z. Sleeves shall be protected throughout the course of construction, and when damaged shall be replace and/or repaired to a satisfactory condition.

3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire/smoke-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 JOINT SEALERS

A. Preparation for Joint Sealers

1. Clean surfaces of penetrations, sleeves, or both, immediately before applying joint sealers, to comply with recommendations of joint sealer manufacturer.
2. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

B. Application of Joint Sealers

1. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

    a. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
    b. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

2. Tooling: Immediately after sealant application and prior to time shining or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical raceways penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which

penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.6 ACOUSTICAL PENETRATIONS

A. Do not allow direct contact of raceways with shaft walls, floor slabs and/or partitions. Sleeve, pack and seal airtight with foam rod, non-hardening sealant and/or packing material, as described herein, for all penetrations by raceway, through surfaces that encompass or are between noise critical spaces. Seal and pack with caulking for the full depth of the penetration all openings around raceways in the structure surrounding the electrical equipment and surrounding noise-critical spaces. This includes all slab penetrations and penetrations of noise critical walls.

B. Where a raceway passes through a wall, ceiling or floor slab of a noise critical space, cast or grout a metal sleeve into the structure. The internal diameter or dimensions of the sleeve shall be 2 inches larger than the external diameter or dimensions of the raceway passing through it. After all of the raceways are installed in that area, check the clearances and correct, if necessary, to within 1/2-inch. Pack the voids full depth with packing material sealed at both ends, 1-inch deep, with non-hardening sealant backed by foam rod.

END OF SECTION

SECTION 260502 - EQUIPMENT WIRING SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes limited scope for electrical connections to equipment specified under other sections or divisions, or furnished under separate contracts or by the Owner.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Unless otherwise noted, perform all electrical work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this contract.

B. Coordinate with work described in Division 23 Section "Common Work Results for HVAC".

C. Coordinate with work described in Division 23 Section "Direct-Digital Control for HVAC".

D. Obtain and review shop drawings, product data, and manufacturer's instructions for equipment furnished under other sections.

E. Determine connection locations and rough-in requirements based on shop drawings.

F. Sequence rough-in of electrical connections to coordinate with installation schedule for equipment.

G. Sequence electrical connections to coordinate with start-up schedule for equipment.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".

B. Product data for the following products for:

1. Special connectors

2. Special conductors or cable assemblies.

C. Shop drawings for:

3. Detailing electrical characteristics, wiring diagrams, fabrication and installation for wiring systems.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories:

4. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Authorities Having Jurisdiction.

5. Marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.1 CORDS AND CAPS

A. Attachment Plugs: Conform to NEMA WD 1.

B. Configuration: NEMA WD 6, matching receptacle configuration at outlet provided for equipment, or as required by the equipment manufacturer.

C. Cord: See Paragraph "Flexible Cords" in Division 26 Section "Low-voltage Electrical Power Conductors and Cables".

D. Provide cord size suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify conditions of equipment and installation prior to beginning work.

B. Verify that equipment is ready for connecting, wiring, and energizing.

1.2 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 ELECTRICAL DEVICES

A. Install disconnect switches, controllers, control stations, and control devices (other than temperature control devices) as indicated, specified in other divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.

3.3 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturers' instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquid tight flexible conduit with watertight connectors in damp or wet locations.

C. Make wiring connections using conductors and cable with insulation suitable for temperatures encountered in heat producing equipment.

D. Provide receptacle outlet where connection with attachment plug is indicated. Provide cord and cap where field-supplied attachment plug is indicated on the Drawings.

E. Provide suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

F. Provide interconnecting conduit and wiring between devices and equipment where indicated on the Drawings.

3.4 EQUIPMENT

A. When equipment is delivered in separate parts and field assembled, internal wiring, indicated on Shop Drawings as field wiring, will be provided by the equipment supplier, unless otherwise noted.

B. Provide power connection to all equipment as required and as indicated in the equipment supplier's installation drawings.

C. Provide all control and interlock wiring for all equipment that is not included within the responsibility of Division 22 or 23.

D. Motorized Damper: Provide lockable toggle, pilot lighted disconnect switch in an accessible location at each motor actuator, or group of motor actuators.

3.5 SIGNAGE AND WAYFINDING

A. Provide junction boxes, disconnect switches and grounding per manufacturer's installation drawings.

B. Coordinate rough-in requirements with signage installation instructions.

C. Coordinate box locations and conduit routing with parapets and roof elevations.

D. Provide labelling on all junction boxes and disconnects in accordance with Division 26 section "Identification for Electrical Systems"

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conductors, cables, and cords rated 600V and less.

B. Connectors and terminations rated 600V and less.

1.2 DEFINITIONS

A. The following abbreviations apply to this and other Sections of these specifications:

1. MC: Metal Clad
2. NBR: Acrylonitrile-butadiene rubber
3. NETA ATS: Acceptance Testing Specification.

B. The following definitions apply to this and other Sections of these Specifications:

1. HOMERUN: That portion of an electrical circuit beginning at a junction box, termination box, receptacle or switch with termination at an electrical panelboard.

    a. Note: Where MC Cable is allowed to be utilized for receptacle and/or lighting branch circuiting loads, the originating point of the homerun shall be at the first load in the circuit or at a junction box in an accessible ceiling space immediately above the first (most upstream) load.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop and temperature deration.
2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
3. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

B. Notify Contract Administrator of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":

1. Product data for the following products:

    a. Conductors, cables, and cords rated 600V and less.
    b. Metal Clad (MC) cable and fittings.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.

C. Design Data: Indicate voltage drop and ampacity calculations for aluminum conductors substituted for copper conductors. Include proposed modifications to raceways, boxes, wiring gutters, enclosures, etc. to accommodate substituted conductors.

D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

E. Qualification Data: For testing agency.

F. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.

G. Operation and Maintenance Data: For cable and all accessories to include in operation and maintenance manuals.

H. Follow-up service reports.

1.5 QUALITY ASSURANCE

A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.

B. Provide products listed and classified by Underwriters Laboratories, Inc (UL) as suitable for the purpose specified and indicated.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

D. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."

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

F. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Contract Administrator and obtain direction before proceeding with work.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner, or others, unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Contract Administrator and the Owner no fewer than 7 days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Contract Administrator and the Owner's written permission.
3. Owner reserves the right to require Contractor to cease work in any area Owner requires access to on an emergency basis.

C. Make every effort to schedule outages during non-business or off-peak business hours to minimize disruptions to business operations.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

PART 2 - PRODUCTS AND MATERIALS

2.1 CONDUCTORS AND CABLES - GENERAL

A. Manufacturers, unless noted otherwise:

1. AFC Cable Systems, Inc.
2. Alan Wire
3. Cerrowire
4. Colonial Wire & Cable
5. Encore Wire Corporation
6. General Cable
7. Northern Cables Inc.
8. Okonite Company
9. Southwire Company

B. Conductor Material: Annealed (soft) copper complying with ICEA S-95-658/NEMA WC70 and UL Standards 44 or 83, as applicable.

1. Solid conductors for No. 10 AWG and smaller; concentric, compressed stranded for No. 8 AWG and larger
2. Stranded conductors
3. Stranded for all flexible cords, cables, and control wiring.
4. As noted otherwise below.

C. Aluminum conductors are not allowed.

D. Conductor Insulation: Type THHN/THWN-2 complying with ICEA S-95-658/NEMA WC70.

E. Sizes of conductors and cables indicated or specified are American Wire Gage (Brown and Sharpe).

F. Unless indicated otherwise, special purpose conductors and cables, such as low voltage control and shielded instrument wiring, shall be as recommended by the system equipment manufacturer.

G. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

2.2 SINGLE CONDUCTORS

A. 600V, insulated conductors as noted above shall be color-coded as follows, unless noted otherwise:

PHASE	208Y/120V	480Y/277V
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	Gray**
Equipment Ground	Green	Green
Isolated Ground	Green/Yellow Stripe	Green/Yellow Stripe

**Except as provided in NFPA 70.

B. Conductors shall not be smaller than No. 12 AWG, with the exception of wiring for signal and pilot control circuits; and pre-manufactured whips for light fixtures which may be No. 14 AWG.

C. Conductors installed for site electrical work shall be no smaller than No. 10 AWG CU. All site electrical branch circuit wiring shall be sized such that the maximum branch circuit voltage drop is less than 3 percent.

2.3 METAL CLAD CABLE; TYPE MC

A. MC Cable (with insulated green grounding conductor, no bonding conductor):

1. Manufacturers:

   a. AFC Cable Systems, Inc. (MC Lite)
   b. Encore Wire Corporation (MC)
   c. Kaf-Tech
   d. Southwire Company (Amorlite)

2. 600V, Unjacketed and/or PVC-jacketed UL Standard 83, UL Standard 1569 for Type MC, UL Standard 1685, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and NFPA 70. Type MC Cable shall be listed for use in UL 1, 2, and 3 Hour Through-Penetration Firestop Systems.
3. Armor Assembly: Aluminum interlocked armor (aluminum color).
4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
5. Grounding Conductor: Solid soft-drawn copper, THHN/THWN-2 green insulated grounding conductor sized per NFPA 70.
6. Marking: Cable markings shall comply with the requirements of NFPA 70.

B. MC Cable (with 0-10V dimming control wiring):

1. Manufacturers:

a. AFC Cable Systems, Inc. (MC- PCS)
b. Encore Wire Corporation (MC- LED)
c. Southwire Company (MC – PCS Duo)

2. 600V, Unjacketed and/or PVC-jacketed UL Standard 83, UL Standard 1569 for Type MC, UL Standard 1685, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and NFPA 70. Type MC Cable shall be listed for use in UL 1, 2, and 3 Hour Through-Penetration Firestop Systems.
3. Armor Assembly: Aluminum interlocked armor (aluminum color).
4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
5. Grounding Conductor: Solid soft-drawn copper, THHN/THWN-2 green insulated grounding conductor sized per NFPA 70.
6. Control Conductors: Color-coded Class 2/Class 3 twisted jacketed pairs
7. Marking: Cable markings shall comply with the requirements of NFPA 70.

C. MC Cable Fittings:

1. Manufacturer & Model:

a. Arlington (4010 AST snap-in type): (SG38 saddle type)
b. Crouse-Hinds (QLK Quick-Lok Series, Saddle type); ACB Series; set-screw, saddle type)
c. O-Z Gedney (AMC-50 speed-lok, saddle type)
d. Thomas & Betts (XC-730 Series cable-lok, saddle type); 3110 Series Tite-Bite)

2. Fittings used for connecting Type MC cable to boxes, cabinets, or other equipment shall be UL listed and identified for such use with an MCI-A marking on the fitting carton or package.
3. Fittings shall be insulated type not requiring the use of anti-short bushings.
4. Romex style, clamp type fittings are not acceptable.

2.4 FLEXIBLE CORDS

A. 600V, multi-conductor (2, 3, or 4 as indicated on the Drawings), oil-resistant black jacket, extra-hard-usage; Type SEO or SO for indoor dry and damp locations; SEOW or SOW for damp, wet, and outdoor locations; or as required by the manufacturer of the equipment to which the cords are connected.

2.5 CONTROL WIRING

A. Refer to Division 23 Section "Direct-Digital Control for HVAC".

B. Unless otherwise noted, all control wiring will be the responsibility of the Section or Division in which the control system is specified.

2.6 CONNECTORS

A. Manufacturers:

1. AMP; Tyco
2. FCI-Burndy
3. Gould
4. Ideal Industries, Inc.
5. Ilsco
6. NSi Industries, Inc.
7. O-Z/Gedney
8. Panduit
9. Thomas and Betts
10. 3-M Electrical Products Division

B. Compression connectors for conductors No. 8 AWG and larger: Long-barreled, UL 486-listed, circumferential compression type (Burndy "Hylug", or equal), insulated with clamp-on, cold-shrink, or molded covers, or wrapped with multiple over-lapping layers of 3-M Scotch electrical tape.

1. Termination fittings for copper conductors: Bare copper, 1 or 2-hole pad and inspection port.

C. Mechanical connections for conductors No. 8 AWG and larger: UL-listed, dual-rated, mechanical type, insulated with clamp-on, cold-shrink, or molded covers, or wrapped with multiple over-lapping layers of 3-M Scotch electrical tape.

1. Termination fittings: Bare copper, 1 or 2-hole pad and inspection port.

D. Connectors for solid conductors No. 10 AWG and smaller: Insulated winged wire nuts. Color-coded for size, except use green only for grounding connections.

E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.

F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

PART 3 - EXECUTION

3.1 PREPERATION

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

B. Coordinate seals with wall, ceiling, roof or floor materials and rating of the surface (sound, fire, waterproofing, etc.)

C. Electrical conductor and cable work is schematically represented on the Drawings. Unless otherwise indicated, conductor sizes shown on the Drawings are based on not more than three single current-carrying conductors in a raceway in free air. Current ratings are based on copper at 75 degrees C temperature rating for all power circuits. Modify raceway and conductor sizing as may be necessitated by any deviation from these conditions. Do not decrease the indicated conductor size due to the use of conductors having a temperature rating of 90 degrees C.

D. Conductor sizes shown are minimum based on code requirements, voltage drop, and/or other considerations. Where approved by the Engineer and at no extra cost to the Owner, larger conductor sizes may be installed at Contractor's option in order to utilize stock sizes, provided raceway sizes are increased where necessary to conform with NFPA 70 (determine the effect of the use of larger conductors on the short circuit current ratings of the electrical equipment, and provide increased short circuit current rated equipment as required).

E. Where anticipated conductor installed lengths exceed the lengths indicated on the Drawings, notify Contract Administrator. Provide tabulated list of exceeded lengths for review. Increase conductor size, circuit ground size, and conduit size accordingly to meet maximum voltage drop indicated within the calculations.

3.2 INSTALLATION

A. General

1. Unless otherwise indicated on the Drawings on in other Sections, install all conductors in raceway. Install continuous conductors between outlets, devices and boxes without splices or taps. Do not pull connections into raceways. Leave at least 12 inches of conductor at outlets for fixture or device connections.
2. Install in accordance with manufacturer's instructions.
3. Use manufacturer-approved pulling compound or lubricant where necessary; compound used shall not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
4. Use pulling means, including fish tape, cable, rope, and basket weave conductor/cable grips that will not damage conductors/cables or raceway.
5. Where parallel conductors are shown, install each set of conductors in separate raceways of essentially the same length.
6. Seal around cables penetrating fire-rated elements according to Division 07 Section "Penetration Firestopping".
7. Wiring at Outlets: Install conductors at each outlet with at least 8 inches of slack.
8. Common or Shared Neutrals are not allowed unless shown on the plans or specifically noted to be allowed.
9. Multi-wire branch circuits are not allowed unless noted otherwise on the drawings.
10. Where multi-wire branch circuits are utilized (i.e., shared neutral), shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point the branch circuit originates. Multi-pole breakers or 3 single pole breakers with a handle tie are two examples.
11. When multiple home runs are combined into a single raceway such that the number of conductors exceeds four (conductor count is made up of any combination of phase and neutral conductors), the following restrictions apply, which are in addition to those in NFPA 70:
    a. Normal or Non-Essential circuits.
        1) Maximum of 16 conductors in a single raceway. For up to eight conductors in a raceway, minimum raceway size: 3/4 inch. For greater than eight conductors, minimum raceway size: 1 inch. Do not install any other type of circuit in this raceway.
        2) The minimum wire size for all conductors in this raceway: No. 10 AWG.
        3) Only 15A and 20A branch circuit homeruns may be combined into one raceway.
    b. GFCI-protected circuits.

1) Do not use multi-conductor circuits, with a shared neutral, for any GFCI circuit breaker or receptacle circuit.

12. For branch circuits fed from GFCI circuit breakers, limit the one-way conductor length to 100 feet between the panelboard and the most remote receptacle or load on the GFCI circuit.
13. Where the number of conductors for branch circuits is not shown on the Drawings, determine the number of conductors in accordance with NFPA 70. Provide adequate conductors so as to allow performance of all functions of the device.
14. Branch circuit conductors shall be copper.
15. Provide all conductors with 600V insulation of the following types, unless otherwise noted on the Drawings or in these Specifications:

a. Wet or dry locations, in raceways:

1) Service entrance: Type THWN, THHN/THWN-2, or XHHW.
2) Feeders and branch circuits: Type THWN, THHN/THWN-2, or XHHW.
3) Conductors No. 6 AWG and smaller: Types THWN or THHN/THWN-2.

B. Metal Clad Type MC Cable:

1. Securing and Supporting:

a. Support per NFPA 70 for MC cable
b. Secure cable within 12 inches of every box or fitting.
c. Secure/supporting intervals shall not exceed six (6) feet for MC cable.
d. Utilize steel cable hangers, Arlington SMC series or equivalent, for MC cable support wherever possible so as to provide for cable routing in a neat and workmanship like manner.

2. Type MC cable may only be used:

a. In lieu of flexible conduit and wiring from light fixtures in accessible ceilings to junction boxes (attached to building structure) above the ceiling. Provide cable whips of sufficient lengths to allow for relocating each light fixture within a 5-foot radius of its installed location, but not exceeding 6 feet in unsupported lengths.
b. For vertical drops and horizontal wiring in stud walls.
c. In lieu of metal raceway, only for 15A and 20A branch circuits with up to four (4) conductors, not including grounding and/or bonding conductor(s), and only in dry concealed locations above grade, except where specifically not permitted by NFPA 70.

3. MC cable shall not be used for any use not listed in the paragraph above. Examples of those uses include, but are not limited to:

a. Unjacketed MC

1) In locations not permitted by NFPA 70.
2) When specifically not allowed by the local AHJ and/or Owner.
3) Homeruns to panelboards.
4) Where exposed to view.
5) Where subject to physical damage.
6) Wet locations.
7) Branch circuits serving HVAC loads.
8) Within mechanical, electrical or telecommunication equipment rooms.

C. Flexible Cords

1. Refer to Division 26 Section, "Equipment Wiring Systems", for electrical connections to equipment.

D. Control Wiring

1. Unless otherwise indicated on the Drawings or in other sections, install all control wiring in raceway, regardless of voltage. A qualified Electrician shall install all control wire operating at 120V nominal and above. Control wiring operating at less than 120V (e.g., 12V and 24V) may be installed under the Division furnishing it.
2. Open wiring in air-handling plenums: UL listed and classified for use in air plenums without raceway. Where indicated on the Drawings or otherwise specified, and permitted by local codes, only cable for communication or fire alarm systems and low voltage control wiring may be installed without raceways.

    a. Low voltage wiring not routed in a race way shall be supported by cable tray or j-hooks secured independently of ceiling supports. Cabling shall not be supported directly by the ceiling system.

E. Connections:

1. Apply a zinc based, anti-oxidizing compound to connections.
2. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
3. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
4. Use only resin pressure splices and splicing kits that totally encapsulate the splice for splices in underground junction boxes. Arrange the splicing kit to minimize the effects of moisture.
5. Use connectors as indicated in equipment schedules. Where not indicated use connections as noted below.

    a. Compression – Conductors No. 8 AWG and larger to panelboards, switchboards and apparatus
    b. Compression – splices, terminals
    c. Mechanical – where temporary removal is required

6. Do not use terminals on wiring devices to feed through to the next device.

3.3 IDENTIFICATION

A. General: Provide all identification per Division 26 "Identification for Electrical Systems".

B. Single Conductors: Identify and color-code conductors to indicate voltage and phase according to Part 2 of this Section. Identification method shall be either:

1. Factory provided colored insulation
2. Color-Coding Conductor Tape.
3. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

C. Power-Circuit Conductor Identification: For primary and secondary conductors 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes identify voltage, source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in the same junction or pull box identify each ungrounded conductor according to voltage, source and circuit number.

E. Conductors to Be Extended in the Future: Attach identification device to conductors and list source and circuit number.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

G. Conductors for controls (lighting, controls): Label each conductor with Markers for Conductor and Control Cables. – identify conductors using method as noted in Division 26 Section "Identification for Electrical Systems". Note conductor identification on record Drawings.

H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

I. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

J. Low voltage cable sheath labels and related manufacturer information shall remain apparent in all exposed applications.

1. Protect exposed cabling labels from painting and overspray (this includes protection of cables in cable tray)

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements. Test all wiring prior to energizing to ensure that it is free from unintentional grounds and shorts, is properly phased, and that all connectors are tight.
2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3. Certify compliance with test parameters.

B. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

B. This Section includes:

1. Grounding Electrodes
2. Ground Bars
3. Grounding Conductors
4. Connector Products
5. Miscellaneous Grounding Materials and Products

1.2 DEFINITIONS

A. The following apply to this and other Sections of these Specifications:

1. Ground ring: Bare underground grounding conductor encircling the building or structure.
2. NETA ATS: Acceptance Testing Specification.
3. PSF: Pounds per Square Foot
4. EMT: Electrical metallic tubing.
5. ENT: Electrical nonmetallic tubing.
6. FMC: Flexible metal conduit.
7. GRS: Galvanized Rigid Steel Conduit
8. IMC: Intermediate metal conduit.
9. LFMC: Liquidtight flexible metal conduit.
10. LFNC: Liquidtight flexible nonmetallic conduit.
11. RAC: Rigid Aluminum Conduit
12. RMC: Rigid Metal Conduit
13. RNC: Rigid nonmetallic conduit.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":

1. Product data for the following products:

a. Electrodes, mechanical and compression connectors, and exothermic connectors .

B. Qualification Data: For Contractor.

C. Quality-Control Test Reports:

1. Test procedures used.

2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":

1. Accurately record actual locations of all buried electrodes, bonding conductors and ground rings. Indicate dimensions from fixed structural elements.

1.4 QUALITY ASSURANCE

A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.

B. Test Equipment Suitability and Calibration: Comply with NETA ATS, "Suitability of Test Equipment" and "Test Instrument Calibration."

C. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
2. Marked for intended use.
3. Comply with UL 467.

E. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

F. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.1 GROUNDING CONDUCTORS, CONNECTORS, AND ELECTRODES:

A. Manufacturers:

1. ABB, Inc.
2. Advanced Lightning Technology (ALT)
3. AFL Global
4. Boggs, Inc.
5. Burndy; Hubbell.
6. Cooper Power; Eaton.
7. Copperweld Corp.
8. ECN/Korns; Division of Robroy Industries.
9. Erico; nVent.
10. Galvan Industries, Inc.
11. Greaves Corp.
12. Harger.

13. Hastings Fiber Glass Products, Inc.
14. Heary Brothers Lightning Protection Co.
15. Ideal Industries, Inc.
16. ILSCO.
17. Lightning Master Corp.
18. Lyncole XIT Grounding; Division of VFC.
19. O-Z/Gedney Co.; Emerson.
20. Panduit, Inc
21. RACO; Hubbell, Inc.
22. Robbins Lightning, Inc.
23. Superior Grounding Systems, Inc.

2.2 GROUNDING ELECTRODES

A. Ground Rods: UL-listed:

1. Copper-clad steel; bonded copper electrolytically-applied to minimum thickness of 10 mils.
2. Size: 5/8 inch by 8 feet.

B. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a bare conductor sized, at a minimum, for the size of the connecting grounding electrode conductor.

C. Ground Plates: UL-listed, rectangular, bare solid copper plate; minimum 0.032-inch thick.

D. Ground Ring:

1. Bare copper grounding conductor, size as noted on Drawings but not less than #2/0 AWG.

2.3 GROUND BARS

A. General

1. Ground bars described in this section are intended to be wall mounted bars used for grounding and bonding. Equipment ground buses for switchboards, panelboards and miscellaneous equipment are described in the individual equipment sections.
2. Supports: Minimum of two each 1-1/2-inch insulators and 1-inch stainless steel offset mounting brackets.

B. Electrical Room Ground Bars

2. Rectangluar Ground Bars: bare, ¼ inch thick, electrolytic, tough pitch copper bar, 4 inches wide. Length as indicated on the Drawings but not less 24 inches long. Hole spacing as required for conductor lugs.

C. Telecommunications Main Grounding Busbar (TMGB)

1. Rectangular Ground Bars: UL & cUL Listed to UL467 & C22.2 respectively, pre-drilled per TIA/EIA Standard 607A, bare, 1/4 inch thick, electrolytic, tough pitch copper bar, 4 inches wide. Length as indicated on the Drawings but not less than 24 inches long.

2.4 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".

B. Material:
   3. Copper.

C. Equipment Grounding Conductors: Insulated and identified as indicated in Part 3 of this section.

D. Isolated Ground Conductors: Insulated and identified as indicated in Part 3 of this section.

E. Grounding Electrode Conductors: Bare, stranded, unless otherwise indicated.

F. Underground Conductors:

   4. Tinned or Bare-copper conductor.
   5. No. 2/0 AWG minimum
   6. Stranded unless otherwise indicated.

G. Bare Copper Conductors:

   1. Solid Conductors: Comply with Conductors: ASTM B 8.
   2. Tinned Conductors: Comply with ASTM B 33.

H. Copper Bonding Conductors:

   1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.
   2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
   3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
   4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches (wide and 1/16 inch thick.

2.5 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors.

C. Compression Connectors: Burndy Hyground, or equal, permanent, pure, wrought copper, meeting ASTM 8 1 87, essentially the same as the conductors being connected; clearly and permanently marked with the information listed below:

   7. Company symbol and/or logo.
   8. Catalog number.
   9. Conductors accommodated.
   10. Installation die index number or die catalog number is required.
   11. Underwriters Laboratories "Listing Mark:".

12. The words "Suitable for Direct Burial" or, where space is limited, "Direct Burial" or "Burial" per UL Standard ANSI/UL467.

D. Cast connectors: copper base alloy according to ASTM B 30.

E. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.6 MISCELLANEOUS

A. Test Wells:

1. Traffic Areas: Polymer concrete reinforced with heavy weave fiberglass; H-20 load rating; minimum 24 inches deep.
2. Non-traffic Areas: High density polyethylene; 350 PSF minimum load rating; minimum 10.25 inches deep.
3. Cover: Factory-identified by permanent means with word "GROUND".

B. Ground Enhancing Backfill: Provide low-resistivity, ground-enhancing backfill material recommended by the electrode manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine areas and conditions under which electrical grounding connections are to be made and notify the Contract Administrator and the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:

13. Provide all materials, labor and equipment for an electrical grounding system in accordance with applicable portions of NFPA 70 and NECA. Coordinate electrical work as necessary to interface installation of electrical grounding systems with other work.
14. Accomplish grounding and bonding of electrical installations and specific requirements for systems, circuits and equipment required to be grounded for both temporary and permanent construction.
15. Where the size of the grounding conductors are not shown, size in accordance with NFPA 70 Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Application:

16. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

17. Underground Grounding Conductors: Unless noted otherwise, bury at least 24 inches below grade, or 6 inches below the official frost line, whichever is greater, or when crossing a duct bank, bury 12 inches above duct bank.

B. Grounding Electrode System: Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.

1. Provide continuous grounding electrode conductors without splice or joint.
2. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
3. Ground Rod Electrodes:

    a. Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
    b. Unless otherwise indicated, install ground rod electrodes vertically.

        1) Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
        2) Indoor Installations: Unless otherwise indicated, install with 4 inches of top of rod exposed.

    c. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70. If depth is unachievable, notify Contract Administrator and Engineer.
    d. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.
    e. Verify that final backfill and compaction has been completed before driving rod electrodes.
4. Ground Plate Electrodes: Unless otherwise indicated, install ground plate electrodes at a depth of not less than 30 inches. Use exothermic weld to secure grounding electrode conductor.
5. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare, tinned copper conductor not smaller than No. 4 AWG. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor above footer and foundation and connect to building structural steel or other grounding electrode external to concrete.
6. Metal Water Service Pipe: Provide 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 by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
7. Ground Ring Electrode (Counterpoise):

    a. Provide a ground ring encircling the building or structure, in direct contact with earth., installed at a depth of not less than 18 inches or 6 inches below the official frost line, whichever is greater.
    b. Locate ground ring conductor at least 24 inches outside building perimeter foundation, unless noted otherwise on the Drawings.
    c. Provide ground enhancement material around conductor where indicated.

8. Metal In-Ground Support Structures: Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with NFPA 70.

9. Metal Poles Supporting Outdoor Luminaires: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

C. Equipment Grounding Conductors:

1. Comply with NFPA 70, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
2. Install equipment grounding conductors in all feeders and branch circuits.
3. In branch circuit and feeder raceways, use insulated equipment grounding conductors.
4. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
5. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components. On water heaters, bond metal hot and cold water pipes together, across the heater tank.
6. Metallic Cable Tray Systems: Install equipment grounding conductor in each cable tray. Do not use metal cable tray system as sole equipment grounding conductor.

    a. Equipment Grounding Conductor for Steel Cable Tray: Use bare or insulated copper conductor.
    b. Equipment Grounding Conductor for Aluminum Cable Tray: Use insulated copper conductor only; do not use bare copper conductor.
    c. Minimum Equipment Grounding Conductor Size: 6 AWG copper.

7. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

D. Ground Bars:

1. Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.

    a. Use insulated spacers and mounting brackets, and support from wall 2 feet above finished floor, unless otherwise indicated.

C. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 6 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 ground bar.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

D. Separately Derived Systems: Bond the derived neutral (grounded) conductor of all separately derived system (e.g., transformers, generators, UPS) to the nearest available grounding electrode, or back to the service grounding electrode if no approved electrodes are readily available. Size the grounding electrode conductor and bonding jumpers as indicated on the Drawings or as required by NFPA 70, whichever is larger.

E. Bonding: Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical

conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70:

1. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
2. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.
3. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.
4. Bond metallic elements likely to become energized or where indicated on the Drawings, including but not limited to fences around electrical equipment and metal drain bodies near pools or electrical equipment.
5. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
6. Common Ground Bonding 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 PVC conduit.
7. Bond the components within the following systems to the building grounding system:

    a. Metallic Cable Tray Systems.

1.2 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible. Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by the manufacturers for indicated applications. Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, and bonding straps as recommended by the manufacturers for types of service indicated.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Replace welds that are puffed up or that show convex surfaces indicating improper cleaning. Use exothermic welded connections for the following:

1. Connecting conductors together.
2. Connecting conductors to ground rods, except at test wells.
3. Connecting conductors to building steel.
4. Connecting conductors to plates.

C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

1. Compression Fittings: Permanent compression-type fittings may be used for the following rather than exothermic connections:

a. Connecting conductors together.
b. Connecting conductors to building steel.
c. Connecting conductors to ground rods, except at test wells.

D. Mechanical Pressure-Type Connections: Tighten screws and bolts for grounding and bonding 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.

1. Mechanical Pressure Fittings: Use bolted mechanical (removable) pressure-type clamps for the following:

a. Connecting conductors to ground rods at test wells.
b. Connecting conductors to pipes.

E. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

F. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

G. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

1.3 GROUND RING

A. Ground the steel framework of the building with a buried electrode at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Protect taps for steel framing connections from physical damage at foundations and transitions to steel columns.

3.3 IDENTIFICATION

A. Provide identification as specified in Division 26 "Low-Voltage Electrical Power Conductors and Cables" and "Identification for Electrical Systems".

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. 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. Measure ground resistance not less than two full days after the last trace of precipitation, and without the 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. Perform tests by the fall-of-potential method according to IEEE 81.
3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
4. Inspect and test in accordance with NETA ATS, except Section 4.
5. Perform inspections and tests listed in NETA ATS, Section 7.13.
6. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
7. Perform point–to–point megohmmeter tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
8. Test Values:
    a. The resistance between the main grounding electrode and earth ground shall be no greater than 5 ohms.
    b. Equipment Rated 500 kVA and Less: 10 ohms.
9. Minimum system neutral–to-ground insulation resistance: one megohm.
10. Investigate point-to-point resistance values that exceed 0.5 ohms.
    a. Check for loose connections.
    b. Check for absent or broken connections.
    c. Check for poor quality welds.
    d. Consider other reasons.
11. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements
12. Excessive Grounding Electrode Resistance: If measured resistance to earth ground value exceeds specified values, add grounding electrodes and additional conductors as required to obtain the specified value.
13. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.5 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 31 and 32. Maintain restored surfaces. Restore disturbed paving as indicated.

1.4 EXISTING INSTALLATIONS

A. Where existing grounding and bonding system components are indicated to be reused, they may be reused only where they are free from corrosion, integrity and continuity are verified, and where acceptable to the authority having jurisdiction.

B. Where applicable, verify the neutral and ground are properly bonded at the point of service entrance. Notify the Owner and the Engineer of any existing deficiencies.

END OF SECTION

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Contract Administrator of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
6. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
7. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in path of conduit groups with supports.
2. HVAC items, plumbing items and architectural features in the paths of conduit groups with common supports.

C. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Submit fabrication drawings and product literature.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.
3. Rooftop support systems.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70 and applicable building code.

C. Installer Qualifications for Powder-Actuated Fasteners: Certified by fastener system manufacturer with current operator's license.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. General:

1. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.

B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly. Use corrosion resistant materials suitable for the environment where installed.

1. Manufacturers:

a. Allied Tube & Conduit; Atkore International.
b. Eaton

c. Erico; nVent.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Atkore International.
g. Wesanco, Inc.

2. Metallic Coatings:

a. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
b. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.

3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

C. 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:

a. Allied Tube & Conduit.
b. Eaton.
c. Enduro Composites.
d. Fabco Plastics Wholesale Limited.
e. 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.
5. Flammability: Fire retardant with NFPA 101, Class A flame spread index (maximum of 25) when tested in accordance with ASTM E84; self-extinguishing in accordance with ASTM D635.

D. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

E. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

1. Conduit Straps: One-hole or two-hole type.
2. Conduit Clamps: Bolted type unless otherwise indicated.

F. 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.

G. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

H. 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:

1) Hilti Inc.
2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Powers Fasteners, Inc;
5) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Manufacturers:

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 zinc-plated steel unless otherwise indicated.

2.2 FABRICATED METAL CONDUIT OR 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.

C. Rooftop support assemblies: Steel pedestals with thermoplastic or rubber bases that rest on top of roofing membrane.

1. Conduit supports: Unless noted otherwise, surface mounted fittings not requiring any attachment to the roof structure and not penetrating the roofing assembly with support fixtures.
2. Equipment supports: Attachment fittings for connection to roof structure.

D. Base Sizes: As required to prevent overturning and to distribute load sufficiently to prevent indentation of roofing assembly.

E. Mounting Height: Provide minimum clearance of 6 inches under supported components to top of roofing.

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. Unless specifically indicated or approved by the Contract Administrator and Structural Engineer, do not support from roof deck.

C. Where support wires are permitted, identify independent electrical component support wires above accessible ceilings with color distinguishable from ceiling support wires in accordance with NFPA 70.

D. Steel Components: Use corrosion resistant materials suitable for the environment where installed.

1. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
2. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.

E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway:

1. Minimum rod size shall be 1/4 inch (6 mm) in diameter, unless otherwise indicated.

    a. Equipment Supports: 1/2 inch diameter minimum.
    b. Busway Supports: 1/2 inch diameter minimum.
    c. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter minimum.
    d. Trapeze Support for Multiple Conduits: 3/8 inch diameter minimum.

2. Space supports for EMT, IMC, and RMC as required by NFPA 70.

F. 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:

    a. two-bolt conduit clamps

G. 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. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Install in accordance with manufacturer's instructions.

E. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

F. 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).

1. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 1.5. Include consideration for vibration, equipment operation, and shock loads where applicable.

G. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.

H. Do not use products for applications other than as permitted by NFPA 70 and product listing.

I. Remove temporary supports when no longer required.

J. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.

K. 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.

    a. 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.

5. To Steel:

    a. Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts
    b. Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
6. To Light Steel: Sheet metal screws.
7. 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.

L. 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.

D. Minimize overhanging materials and protrusions, and provide protective caps and fittings on exposed material ends where:

1. Accessible to untrained personnel.
2. Located within confined spaces.

E. Rooftop support assemblies:

1. Conduit supports: Unless noted otherwise, coordinate installation of support system after roofing materials are complete. Provide adhesive materials to secure conduit supports where required. Where attachment to roof structure is required or otherwise specified, coordinate installation of supports with roofing material installation.
2. Equipment supports: Coordinate installation of supports with roofing material installation.

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 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 "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).

B. Comply with requirements in Division 09 "Finishes" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

D. Inspect support and attachment components for damage and defects. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL REQUREMENTS

1.1 SECTION INCLUDES

A. This Section includes:

1. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.2 DEFINITIONS

A. Terminology used in this specification is as defined below:

1. EMT: Electrical Metallic Tubing
2. FMC: Flexible Metal Conduit
3. GRS: Galvanized Rigid Steel Conduit
4. IMC: Intermediate Metal Conduit
5. LFMC: Liquidtight Flexible Metal Conduit
6. LFNC: Liquidtight Flexible Nonmetallic Conduit
7. RAC: Rigid Aluminum Conduit
8. RMC: Rigid Metal Conduit
9. RNC: Rigid Nonmetallic Conduit

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the work with other trades to avoid placement of raceway, boxes, or other potential obstructions within the dedicated equipment spaces and working clearances for equipment installed by other trades in accordance with the codes and manufacturer requirements.
2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
6. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated. Coordinate the work with other trades to preserve insulation integrity.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".

B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in path of conduit groups with supports.
2. HVAC items, plumbing items and architectural features in the paths of conduit groups with common supports.

C. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":

1. Accurately record actual routing of all exterior buried raceway and all interior raceways three inches and larger. Indicate dimensions from fixed structural elements.

1.5 QUALITY ASSURANCE

A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.

B. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to AHJ.
2. Marked for intended use.

C. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.1 CONDUITS, SURFACE MOUNTED RACEWAYS AND ACCESSORIES

A. Metal Conduit and Tubing

1. Manufacturers:

a. ABB, Inc.
b. AFC Cable Systems, Inc.; a division of Atkore International
c. Allied Tube and Conduit
d. American Conduit
e. Anamet Electrical, Inc.
f. Electri-Flex Co.
g. Nucor Tubular Products.
h. O-Z/Gedney Co.; Emerson.
i. Republic Raceway.
j. Southwire Company, LLC
k. Western Tube and Conduit Corporation.
l. Wheatland Tube Co.

2. RMC:

a. GRS: Hot-dip galvanized: ANSI C80.1, UL 6.
b. RAC: ANSI C80.5, UL6A.

3. IMC: ANSI C80.6, UL 1242.
4. EMT and Fittings: ANSI C80.3, UL 797. Only steel products allowed. Reduced wall EMT is not allowed.

    a. Fittings: Set-screw or Compression type.

5. FMC: Aluminum or Zinc-coated steel: UL 1. Reduced wall FMC is not allowed.
6. LFMC: Flexible steel raceway with PVC jacket: UL 360.

    a. Fittings: NEMA FB 1; compatible with raceway and tubing materials.

B. Nonmetallic Raceway

1. Manufacturers:

    a. ABB, Inc.
    b. AFC Cable Systems, Inc. (Tubing); a division of Atkore International
    c. Allied Tube and Conduit
    d. American Pipe and Plastics, Inc.
    e. Anamet Electrical, Inc.
    f. Arnco Corp.
    g. Cantex Inc.
    h. Champion Fiberglass, Inc.
    i. Electri-Flex Co.
    j. FRE Composites.
    k. Hubbell Inc. (Fittings)
    l. IPEX USA, LLC.
    m. Phoenix Contact.
    n. Prime Conduit.
    o. Southwire Corporation.
    p. Superflex Ltd.
    q. United Fiberglass of America, Inc.

2. RNC: Schedule 40 PVC: NEMA TC 2, UL 651.

    a. Fittings: match to raceway and tubing type and material: NEMA TC 3, NEMA TC 6, UL 651, as applicable.

C. Metal Wireways

1. Manufacturers:

    a. BEL Products, Inc.
    b. Cooper B-Line; Eaton.
    c. EPI-Electrical Enclosures
    d. Hoffman.
    e. Square D.

2. Material and Construction: 14 gauge (minimum) sheet steel, sized and shaped as indicated, NEMA 1.
3. Fittings and Accessories: Include couplings, offsets, elbows, expansion/deflection joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70. Where indicated, provide a barrier to divide wireway into compartments.

4. Wireway Covers:

    a. Hinged type
5. Finish: Manufacturer's standard phosphate pre-treatment and baked enamel finish.

D. Nonmetallic Wireways

1. Manufacturers:

    a. ABB, Inc.
    b. Enduro Composite Systems
    c. Hoffman.

2. Description: Fiberglass reinforced polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Gasketed cover with oil-resistant gasket material.
    a. Snap-On covers and cover splice plates
3. Description: PVC, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
4. Fittings and Accessories: Include couplings, offsets, elbows, expansion/deflection joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
5. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

E. Surface Metal Raceways

1. Manufacturers:

    a. ABB, Inc.
    b. Hubbell, Inc.
    c. Legrand.
    d. Mono-Systems; Niedax Group
    e. Panduit Inc.

2. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating.
3. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.

F. Surface Nonmetallic Raceways

1. Manufacturers:

    a. ABB, Inc.
    b. Enduro Composite Systems.
    c. Hubbell, Inc.
    d. Legrand.
    e. Mono-Systems, Inc.
    f. Panduit Inc.

2. Two-piece construction, manufactured of rigid PVC compound with matte texture and manufacturer's standard color.
3. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways.

2.2 BOXES, ENCLOSURES AND CABINETS

A. General

1. Manufacturers:

a. ABB, Inc.
b. American Midwest Power
c. Appleton/O-Z Gedney Co.; Emerson.
d. BEL Products, Inc.
e. Cooper Crouse-Hinds; Eaton.
f. Erickson Electrical Equipment Co.
g. FSR, Inc.
h. Hoffman.
i. Hubbell, Inc.
j. Legrand.
k. Molex; Koch Industries.
l. Robroy Industries, Inc.; Enclosure Division.
m. Spring City Electrical Manufacturing Co.

2. Provide products listed, classified, and labeled as suitable for the purpose intended. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
3. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:

1. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
2. Cast Metal Boxes: Comply with NEMA FB 1, Type FD, with gasketed cover. Furnish with threaded hubs.

a. List and label as complying with UL 514A for non-hazardous locations;.

3. Nonmetallic Boxes: Comply with NEMA OS 2, and list and label as complying with UL 514C.
4. Boxes for Supporting Luminaires: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
5. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes.
6. Minimum Box Size, Unless Otherwise Indicated:

a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 1-1/2 inch deep (100 by 38 mm) trade size.
b. Communications Systems Outlets: Comply with Section 27 10 05.
c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.

7. Do not use "through-wall" boxes designed for access from both sides of wall.

8. Wall Plates: Comply with Division 26 Section "Wiring Devices".

C. Boxes for telephone, data, telecommunications and audio-video outlets, refer to:
1. Division 27 Section "Common Work Results for Communications"

D. Junction and Pull Boxes Larger Than 100 cubic inches:

1. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1, and list and label as complying with UL 514A.
2. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast iron with gasketed cover.
3. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
4. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.

E. Cabinets and Enclosures:

1. General:

a. Compliance: NEMA 250, and list and label as complying with UL 50 and UL50E or 508A, as applicable.
b. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes: Shall be keyed. Provide 2 keys for each enclosure.

1) All locks shall be keyed alike.

c. NEMA 250 Environment ratings:

1) NEMA Type 1: Code-gauge phosphatized steel with continuously welded seams; non-gasketed removable hinged front cover, with flush latch and concealed hinge; collar studs.
2) NEMA Type 3R: Code-gauge galvanized steel with drip shield top, seam-free front, side, and back; non-gasketed continuous-hinged door, with stainless steel pin; captive, plated steel cover screws; hasp and staple for padlocking; collar studs.

d. Removable painted steel interior panel mounted on standoffs; metal barriers to separate wiring of different systems and voltages.
e. Provide enclosures wider than 36 inches with double doors; removable center posts; internal bracing, supports, or both, as required to maintain their structural integrity; and, accessory feet where required for freestanding equipment.
f. Provide clamps, grids, slotted wireways, or similar devices to which or by which wiring may be secured. Provide DIN-rail mounted terminal strips for terminating all incoming and outgoing control wiring, and power terminal blocks for incoming/outgoing power wiring. Provide wire management troughs where practicable.
g. Provide metal barriers to separate compartments containing control wiring operating at less than 50 volts from power and higher-voltage control wiring.

2.3 FACTORY FINISHES

A. Interior Finish: All interior components shall be factory finished; manufacturer's standard grey unless otherwise noted.

B. Exterior Finish: For metal wireway and surface raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Install in accordance with manufacturer's instructions

3.2 RACEWAYS

A. General

1. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this article are stricter.
2. Provide sizes and types of raceways as indicated on the Drawings. Sizes are based on THWN insulated copper conductors, except where noted otherwise. Where sizes are not shown on the Drawings or in the Specifications, size raceways in accordance with NFPA 70 requirements for the number, size and type of conductors installed. Minimum raceway size: 1/2 inch (concealed and exposed); 1 inch (underground and under slab).

    a. 1/2 inch conduit shall contain maximum (5) #12AWG conductors or (3) #10AWG conductors.
    b. 3/8 inch flexible conduit may be used for light fixture whips.

3. Provide all raceways, fittings, supports, and miscellaneous hardware required for a complete electrical system as described by the Drawings and Specifications.
4. Install a green-insulated, equipment-grounding conductor, which is bonded to the electrical system ground, in all raceways, with the exception of Service Entrance raceways.
5. Install grounding bushings on all conduit terminations and bond to the enclosure, equipment grounding conductor, and electrical system ground.
6. Install raceways concealed in walls or above suspended ceilings in finished areas. When approved by the Contract Administrator, raceways may be installed concealed in elevated floor slabs. Do not install raceways horizontally within slabs on grade.
7. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.
8. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
9. Make bends and offsets so inside diameters are not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
10. Install raceways:

    a. To meet the requirements of the structure and the requirements of all other Work on the Project.
    b. To clear all openings, depressions, ducts, pipes, reinforcing steel, and so on.
    c. Within or passing through the concrete structure in such a manner so as not to adversely affect the integrity of the structure. Become familiar with the Architectural and the Structural Drawings and their requirements affecting the raceway installation. If necessary, consult with the Contract Administrator.
    d. Parallel or perpendicular to building lines or column lines.
    e. Tight to structure.

f. When concealed, with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

11. Raceways Embedded in Slabs:

a. Raceways may only be embedded in concrete slabs with written permission from, and only where directed, by the Structural Engineer.
b. Install in middle 1/3 of slab thickness, where practical. At a minimum, concrete shall provide at least 2 inches of concrete cover for raceways.
c. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
d. Space raceways laterally to prevent voids in concrete.
e. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
f. Change from RNC to coated GRS or IMC before rising above the floor.

12. Where masonry walls are left unfinished, coordinate raceway installations with other trades so that the raceways and boxes are concealed and the wall will have a neat and smooth appearance.
13. Support raceways from structural elements of the building as required by NFPA 70, Division 26 Section "Hangers and Supports for Electrical Systems". Do not support raceways by hangers used for any other systems foreign to the electrical systems; and, do not attach to other foreign systems. Do not lay raceways on top of the ceiling system.

a. Raceways on roof shall be supported from structure not from the roof deck.

14. Provide support spacing in accordance with NFPA 70 requirements, and at a minimum in accordance with NEMA standards. Support by the following methods:

a. Attach single raceway directly to structural steel with beam clamps.
b. Attach single raceway directly to concrete with one-hole clamps or clips and anchors. Outdoors and wherever subject to dampness or moisture, offset raceways from the surface by using galvanized clamps and clamp backs, to mitigate moisture entrapment between raceways and surfaces.
c. Attach groups of raceway to structural steel with slotted support system attached with beam clamps. Attach raceway to slotted channel with approved raceway clamps.
d. Attach groups of raceway to concrete with cast-in-place steel slotted channel fabricated specifically for concrete embedment. Attach raceway to steel slotted channel with approved raceway clamps.
e. Hang plumb horizontally suspended single raceway using a threaded rod. Attach threaded rods to concrete with anchors and to structural steel with beam clamps. Attach raceway to threaded rod with approved raceway clamps.
f. Hang horizontally suspended groups of raceway using steel slotted support system suspended from threaded rods. Attach threaded rods to concrete with anchors and to structural steel with beam clamps. Attach raceway to steel slotted channel with approved raceway clamps.
g. Support conductors in vertical raceway in accordance with NFPA 70 requirements.
h. Cross-brace suspended raceway to prevent lateral movement during seismic activity.
i. Use pre-fabricated non-metallic spacers for parallel runs of underground or under-slab conduits, either direct buried or encased in concrete.

15. Install electrically- and physically-continuous raceways between connections to outlets, boxes, panelboards, cabinets, and other electrical equipment with a minimum possible number of bends and not more than the equivalent of four 90-degree bends between boxes. Make bends smooth and even, without flattening raceway or flaking the finish.
16. Protect all electrical Work against damage during construction. Repair all Work damaged or moved out of line after rough-in, to meet the Contract Administrator's approval, without additional cost to the Owner. Cover or temporarily plug openings in boxes or raceways to keep raceways clean during construction. Clean all raceways prior to pulling conductors or cables.
17. Align and install raceway terminations true and plumb.
18. Complete raceway installation before starting conductor installation.
19. Install a pull cord in each empty raceway that is left empty for installation of wires or cables by other trades or under separate contracts. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull cord.
20. Install approved expansion/deflection fittings where raceways pass through or over building expansion joints; or where structures providing a means of support are subject to relative movement greater than acceptable by the raceway manufacturer.
21. Route raceway through roof openings for piping and ductwork or through roof seals approved by the Contract Administrator, the roofing contractor, or both. Obtain approval for all roof penetrations and seal types from the Contract Administrator, Owner, roofing contractor, or all three as required to maintain new or existing roofing warranties.
22. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-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 at the following points:

    a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces or from building exterior to building interior.
    b. Where otherwise required by NFPA 70.

23. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment as required by other requirements of the construction documents.; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
24. Maintain 2" minimum spacing from bottom of roof deck to prevent raceway penetrations from above.
25. Do not route conduits across skylights, access panels, hatched tiles, HVAC diffusers, or equipment working space.
26. Route conduits serving rooftop equipment concealed inside the equipment curb and minimize roof penetrations and exterior conduit runs where practicable.
27. Install all underground conduits/raceways a minimum of 24" below the bottom of slab/paving/grade, unless noted otherwise, where practicable.
28. Provide boxes and raceways for the fire protection system low voltage wiring as required. This includes low voltage wiring exposed less than 96" AFF.

    a. At a minimum, provide 3/4" conduit.
    b. Coordinate requirements and locations with system installer and fire alarm specifications.

B. RMC

1. Use GRS or IMC in the following areas:

a. Where indicated.
b. Exterior applications where above grade and exposed.
c. Below grade when concrete-encased, plastic-coated, or provided with a corrosion resistant approved mastic coating.
d. All raceways penetrating slabs on grade (use plastic-coated raceway or provide with a corrosion resistant approved mastic coating). This shall include the 90-degree elbow below grade and the entire vertical transition to above grade.
e. Conductors over 600 volts.
f. Concealed within masonry walls.
g. Damp or wet locations.

2. Use RAC in the following areas:

a. Only where specifically indicated on the Drawings.
b. Indoors above grade.
c. Interior wet or damp locations.
d. For circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

3. Do not use RAC:

a. Below grade.
b. Imbedded in concrete or other areas corrosive to RAC.

C. EMT

1. Use EMT in the following areas:

a. Where indicated.
b. Interior concealed locations for:

1) Branch circuits.
2) Feeders.
3) Emergency branch circuits.
4) Low-voltage control, security, and fire alarm circuits

c. Exposed where not subject to physical damage

1) Mechanical rooms

2. Do not use EMT:

a. Below grade.
b. In exterior applications when exposed.

D. FMC and LFMC

1. Use FMC or LFMC:

a. For the final 24 inches of raceway to all motors, transformers, and other equipment subject to vibration or movement.
b. From outlet boxes (attached to building structure) to recessed light fixtures. Install sufficient length to allow for relocating each light fixture within a 5-foot radius of its installed location.
c. Use FMC only in dry locations

2. Do not use FMC or LFMC:

a. For branch circuits, homeruns or feeders.
b. In lengths exceeding 6 feet.

E. RNC

1. Solvent-weld RNC fittings and raceway couplings per the manufacturer's instructions and make all connections watertight. Use solvent of the same manufacturer as the raceway.
2. Where installed exposed outdoors or other areas subject to temperature variations, install expansion fittings per NFPA 70, to accommodate thermal expansion in straight runs.
3. RNC is only allowed to be used in the following locations:

a. Where specifically indicated.

1) If an adopted code prevents use of RNC in a location where the contract documents specifically allows its use, contractor shall utilize other types of conduit allowed by the specification.
2) Allowed does not mean required.

F. Telephone and Signal/Data System Raceways, 2-Inch Trade Size and Smaller: In addition to above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

3.3 RACEWAY FITTINGS:

A. Compatible with raceways and suitable for use and location.

B. RMC and IMC: Use threaded rigid steel conduit fittings, unless otherwise indicated.

C. PVC Externally Coated, Rigid Steel Conduits: Use only fittings and installation tools approved by the manufacturer for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits. Replace all fittings and conduits that have any portion of the coating scraped off to bare metal, at no additional cost to the Owner.

D. Join raceways with fittings designed and approved for that purpose and make joints tight.

E. Use insulating bushings to protect conductors at raceway terminations:

1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.

3.4 WIREWAYS:

A. Use flat head screws, clips and straps to fasten wireways to surfaces. Mount plumb and level.

B. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

C. Close ends of wireway and unused raceway openings.

3.5 BOXES:

A. General

1. Verify locations of device boxes prior to rough in.
2. Set boxes at elevations to accommodate mounting heights as specified or indicated on the Drawings.
3. Electrical boxes are shown on Drawings in approximate locations unless dimensioned. Adjust box locations to accommodate intended purpose.
4. Install boxes to preserve fire ratings of walls, floors, and ceilings.
5. Install flush wall-mounted boxes without damaging wall insulation or reducing its effectiveness.
6. Support boxes independently of raceway.
7. Clean the interior of boxes to remove dust, debris, and other material. Clean exposed surfaces and restore finish.
8. Adjust flush-mounted boxes to make front edges flush with finished wall material.
9. Provide boxes of the depth required for the service, device and the application, and with raised covers set flush with the finished wall surface for boxes concealed in plaster finishes. Select covers with the proper openings for the devices being installed in the boxes. Install boxes flush unless otherwise indicated.
10. Install outlet boxes in firewalls complying with UL requirements, with box surface area not exceeding 16 square inches; and, when installed on opposite sides of the wall, separate by a distance of at least 24 inches.

B. NEMA Enclosure ratings: Suitable for the environment in which it is installed. At a minimum, provide the following ratings:

1. NEMA 250, type 3R

    a. Provide at exterior locations

2. NEMA 250, type 1

    a. Provide at interior and dry locations

C. Outlet Boxes

1. Locations of outlets on Drawings are approximate; and, except where dimensions are shown, determine exact dimensions for locations of outlets from plans, details, sections, or elevations on Drawings, or as directed by Contract Administrator. Locate outlets generally from column centers and finish wall lines or to centers or joints of wall or ceiling panels.
2. Locate outlet boxes so they are not placed back-to-back in the same wall, and in metal stud walls, so they are separated by at least one stud space, to limit sound transmission from room to room. Install outlet boxes in accessible locations and do not install outlets above ducts or behind furring.
3. Install all electrical devices, such as plug receptacles, lamp receptacles, light switches, and light fixtures in or on outlet boxes Use sheet-steel boxes for dry locations unless otherwise indicated or required.
4. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
5. Use cast iron boxes or cast aluminum boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
6. Use cast aluminum boxes where aluminum rigid metal conduit is used.
7. Use nonmetallic boxes where exposed rigid PVC conduit is used.
8. Use suitable concrete type boxes where flush-mounted in concrete.

9. Use suitable masonry type boxes where flush-mounted in masonry walls.
10. Use raised covers suitable for the type of wall construction and device configuration where required.
11. Use shallow boxes where required by the type of wall construction.
12. Install extension and plaster rings as required by NFPA 70.
13. Carefully set outlet boxes concealed in non-plastered block walls so as to line up with wall joints. Coordinate the box and raceway installation with the wall construction as required for a flush and neat appearing installation. Outlet box extensions may be used where necessary.
14. Do not exceed allowable fill per NFPA 70.
15. Where multiple devices are shown grouped together, gang mount with a common cover plate.

D. Junction and Pull Boxes

1. Install junction and pull boxes above accessible ceilings and in unfinished areas.
2. Provide boxes set flush in painted walls or ceilings with primer coated cover.
3. Where junction and pull boxes are installed above an inaccessible ceiling, locate so as to be easily accessible from a ceiling access panel.
4. Boxes for exterior use shall be:

    a. PVC with a UV-stabilized PVC cover sealed and gasketed watertight.
    b. Cast aluminum with a cast aluminum cover sealed and gasketed watertight.
    c. Cast iron with cast iron cover sealed and gasketed watertight in vehicular traffic areas. Provide box and cover UL listed for use in vehicular traffic areas.
    d. Install buried boxes so that box covers are flush with grade, unless indicated otherwise.

3.6 CABINETS AND ENCLOSURES:

A. Unless otherwise indicated on the Drawings, provide

1. NEMA 1 construction for indoor, dry locations
2. NEMA 12 for indoor, damp and dusty locations
3. NEMA 3R for outdoor locations

B. Install flush mounted in the wall in finished spaces, with the top 78 inches above finished floor. The front shall be approximately 3/4-inch larger than the box all around.

C. Install surface mounted in unfinished spaces, with the top 78 inches above finished floor. The front shall be the same height and width as the box.

D. Electrically ground all metallic cabinets and enclosures. Where wiring to cabinet or enclosure includes a grounding conductor, provide a grounding lug in the interior of the cabinet or enclosure. Cabinets and enclosures specified in this Section are intended to house miscellaneous electrical components assembled in a custom arrangement, such as contactors and relays.

E. All components that are specified or indicated for assembly in cabinets and enclosures shall each be individually UL listed and labeled. Arrange wiring so that it can be readily identified. Support wiring no less than every 3 inches. Install gauges, meters, pilot lights and controls on the face of the door.

F. Do not provide cabinets and enclosures smaller than the sizes indicated. Where sizes and types are not indicated, provide cabinets and enclosures of the size, type and classes appropriate for

the use and location per the guidelines of the NEC. Provide all items complete with covers and accessories required for the intended use.

3.7 IDENTIFICATION

A. Refer to Division 26 Section "Identification for Electrical Systems" for identification materials.

B. Raceway Identification:

1. Conduit and raceways are to be color coded for ease of identification. Where a facility standard already exists, that shall be followed. Where no standard exists for color-coding, provide in accordance with table below.

    a. Conduit shall be color-coded from the factory. Junction boxes, fittings, and connectors are not required to be painted to match.
    b. As an alternative, submit deduct to omit use of factory-painted conduit. Tape or paint are to be used to identify conduits and junction boxes and/or fittings are to be painted in accordance with facility standard or color table.

Conduit Service	**Color Description**
Building Automation and Controls	Blue
Fire Alarm	Red
Life Safety Power Branch	Yellow
Critical Power Branch	Orange
Equipment Branch	Green
Emergency Power Distribution Not Listed Above	Purple

2. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size. Use the following means of identification:

    a. Self-Adhesive Vinyl Labels
3. Color for Printed Legend:

    a. Power Circuits: Black letters on an orange field.
    b. Legend: Indicate system or service and voltage, if applicable

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identification device shall be:

1. Self-adhesive vinyl label

D. Accessible Raceways of Auxiliary Systems: Identify the following systems using the same identification device as other accessible raceways 600V or less, and with the indicated color scheme for each system:

1. Fire Alarm System: Red.
2. Fire-Suppression Supervisory and Control System: Red and yellow.
3. Combined Fire Alarm and Security System: Red and blue.
4. Security System: Blue and yellow.
5. Mechanical and Electrical Supervisory System: Green and blue.
6. Telecommunication System: Green and yellow.
7. Control Wiring: Green and red.

E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

F. Junction Boxes and Pull Boxes:

1. Junction box and pull box covers shall be spray painted to identify the voltage and system. Circuit numbers and the panel they originate from shall be listed on the cover using permanent, waterproof, black ink marker.

END OF SECTION

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. This Section includes:

1. Raceways, fittings, boxes, and handholes for direct buried and concrete-encased electrical distribution.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":

1. Product data for the following products:

a. Raceways, Raceway fittings, separators, duct-bank materials, handholes, boxes, solvent cement, warning tape and warning planks.

B. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":

1. Accurately record actual routing of all exterior buried raceway including coordination with other surrounding utilities and underground structures. Provide scaled plans and sections that Indicate dimensions from finished grade or other fixed structural elements.

1.3 DEFINITIONS

A. Terminology used in this specification is as defined below:

1. GRS: Galvanized Rigid Steel Conduit
2. RMC: Rigid Metal Conduit
3. RNC: Rigid Nonmetallic Conduit

1.4 QUALITY ASSURANCE

A. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 3 years.

B. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to AHJ.
2. Marked for intended use.

C. Comply with NFPA 70 and ANSI C2.

D. Test and inspect pre-cast concrete utility structures according to ASTM C 1037.

E. Non-concrete Handhold and Pull-Box Prototype Test: Test prototypes of boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to project site with ends capped and store nonmetallic ducts with supports to prevent bending, warping, and deformation.

B. Store pre-cast and other factory –fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings, if present, are visible.

C. Lift and support pre-cast concrete units only at designated lifting or supporting points.

1.6 PROJECT CONDITIONS

A. Interruption of existing electrical service to occupied facilities shall not occur unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated.

1. Notify Architect no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architects written permission.

1.7 COORDINATION

A. Coordinate layout and installation of ducts, 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 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 handholes, and as approved by the Architect.

PART 2 - PRODUCTS AND MATERIALS

2.1 RACEWAYS AND FITTINGS

A. Metal Conduit

1. Manufacturers:

    a. AFC Cable Systems, Inc.
    b. Alflex Corporation, a Southwire Company
    c. Anamet Electrical, Inc.; Anaconda Metal Hose.
    d. Electri-Flex Co.
    e. Indalex
    f. Manhattan/CDT/Cole-Flex
    g. O-Z/Gedney; Unit of General Signal (Fittings)
    h. Republic Raceway
    i. Tyco International; Allied Tube & Conduit Div.
    j. Wheatland Tube Co.
2. RMC:

    a. GRS: Hot-dip galvanized: ANSI C80.1, UL 6

3. Plastic-Coated GRS and Fittings: NEMA RN 1, UL-listed. Coating thickness of 0.40 inches (1 mm), minimum.
4. Fittings: NEMA FB 1; compatible with raceway and tubing materials.

B. Nonmetallic Raceway

1. Manufacturers:

    a. AFC Cable Systems, Inc. (Tubing)
    b. American International.
    c. Anamet Electrical, Inc.; Anaconda Metal Hose.
    d. Arnco Corp.
    e. Cantex Inc.
    f. Certainteed Corp.; Pipe & Plastics Group.
    g. Condux International.
    h. ElecSYS, Inc.
    i. Electri-Flex Co.
    j. Lamson & Sessions; Carlon Electrical Products.
    k. Manhattan/CDT/Cole-Flex.
    l. RACO; Division of Hubbell, Inc.
    m. Spiralduct, Inc./AFC Cable Systems, Inc.
    n. Superflex Ltd.
    o. Thomas & Betts Corporation.

2. RNC: Schedule 40 (type EPC-40-PVC) PVC: NEMA TC 2, UL 651.

    a. a. Fittings: match to raceway type and material: NEMA TC 3, NEMA TC 6, UL 651, as applicable.

C. DUCT ACCESSORIES

1. Duct Separators shall be factory-fabricated rigid 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. Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."

3. Concrete warning planks shall be nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.

    a. Color: Red dye added to concrete during batching.
    b. Labeling: Mark each plank with "ELECTRICAL" in 2-inch high, 3/8-inch deep letters.

2.2 PRE-CAST CONCRETE HANDHOLES AND BOXES

A. General

1. Manufacturers:

    a. Carder Concrete Products.
    b. Christy Concrete Products
    c. Elmhurst-Chicago Stone Co.
    d. Oldcastle Pre-cast Group
    e. Riverton Concrete Products; a division of Cretex Companies, Inc.
    f. Utility Concrete Products, LLC
    g. Utility Vault Co.
    h. Wausau Title, Inc.

B. Comply with ASTM C858 for design and manufacturing process.

C. Pre-cast concrete handholes and boxes shall be 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 the handhole or box.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

    a. Cover Hinges: Concealed, with hold-open ratchet assembly.
    b. Cover Handle: Recessed.

4. Frame and Cover: Weatherproof aluminum frame, with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

    a. Cover Hinges: Concealed, with hold-open ratchet assembly.
    b. Cover Handle: Recessed.

5. The cover finish shall be a nonskid finish with a minimum coefficient of friction of 0.50.
6. The cover shall have the following legend lettering molded into the cover:
    a. As indicated for each service.
7. Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
8. Extensions and slabs shall be designed to mate with bottom of enclosure and shall be same material as enclosure.

    a. Extension shall provide increased depth of 12 inches.

b. Slab shall be same dimensions as bottom of enclosure, and arranged to provide closure.

9. Duct entrances into handhole walls shall have cast end-bell or duct–terminating fittings in the 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.

10. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.2 UNDERGROUND ENCLOSURE INSTALLATION

A. Handholes and Boxes for 600 volts and Less, Including Telephone, Communications, and Data Wiring:
1. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced Polyester resin structurally tested according to SCTE 77 with 3000-lbf vertical loading.

3.3 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 volts and Less: RNC, NEMA Type EPC-40 PVC, in direct- buried duct bank, unless otherwise indicated.

B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40 PVC, indirect-buried duct bank, unless otherwise indicated.

C. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40 PVC, in concrete-encased or direct-buried duct bank, unless otherwise indicated.

D. Undergrond Ducts Crossing Paved Paths: RNC, NEMA Type EPC-40 PVC, encased in reinforced concrete.

3.4 EARTHWORK

A. Excavation and Backfilling: 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 and compaction is complete.

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."

3.5 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48-inches 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 the same plane.

D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10-inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell with out reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical."

F. Sealing: Provide temporary closure at termination of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling Cord: Install 100-lbf test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet of duct. Secure separators to earth and ducts to prevent floating during concreting. Stagger separators approximately 6-inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around the ducts or duct group.
2. Concreting Sequence: Pour each run of envelope between other terminations in one continuous operation.

    a. Start at one end 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 the 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 ¾-inch reinforcing rod dowels 18-inches into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured with out soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3-inches between ducts and exterior envelope wall, 2-inches between ducts for like services, and 4-inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24-inches below finished grade in areas not subject to deliberate traffic, and at least 30-inches below finished grade in deliberate traffic paths of vehicles, unless otherwise indicated.
8. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3-inches of concrete.
    b. Stub-ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60-inches from edge of base. Install insulated grounding bushings on terminations at equipment.

9. Warning Tape: Bury warning tape approximately 12 inches above all concrete–encased ducts and duct banks. Align tape parallel to and within 3-inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18-inches. Space additional tapes 12-inches apart, horizontally.

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 4 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6-inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6-inches 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 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 run

and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

6. Install ducts with a minimum of 3-inches between ducts for like services and 6-inches between power and signal ducts.
7. Depth: Install top of duct bank at least 36-inches below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3-inches of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60-inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Warning Planks: Bury warning planks approximately 12 inches above all direct-buried ducts an duct banks placing them 24-inches 0.c.. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18-inches. Space additional planks 12-inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE HANDHOLES AND BOXES

A. Precast Concrete Handhole Installation:

1. Comply with ASTM C891, unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:
1. Install handholes with bottom below the frost line, below grade.
2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1-inch above grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRE-CAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

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 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, 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 and boxes with bottom below the frost line, 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 the 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.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.9 INSTALLATION ACCEPTANCE

A. Prior to final acceptance of the duct bank and associated structures, pull an aluminum of wood test mandrel through the duct to prove joint integrity and to verify ducts have not been deformed. Provide mandrel equal to 80 percent fill of the duct. Test duct bank 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." Correct any deficiencies and retest as specified above. Clean internal surfaces of

B. handholes and remove foreign materials.

END OF SECTION

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following:

1. Nameplates.
2. Labels for raceways and metal-clad cable.
3. Labels for junction boxes and pull boxes.
4. Labels for wiring devices and lighting control devices.
5. Markers for conductors, and control cables.
6. Tags.
7. Underground-line warning tape.
8. Warning labels and signs.
9. Arc Flash Warning Labels.
10. Instruction signs.
11. Miscellaneous identification products.
12. Painted Identification.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Where a facility identification standard already exists, that standard shall be continued. Where an identification standard does not exist, color-coding and identification shall be as described herein.

B. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

C. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.

D. Coordinate installation of identifying devices with location of access panels and doors.

E. Install identifying devices before installing acoustical ceilings and similar concealment.

1.3 QUALITY ASSURANCE

A. Electrical Equipment, Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by an NRTL as defined by OSHA in 29 CFR 1910.7 and that are acceptable to authorities having jurisdiction.
2. Marked for intended use.

B. Comply with ANSI A13.1 and ANSI C2.

C. Comply with requirements of NFPA 70.

D. Comply with 29 CFR 1910.145.

PART 2 - PRODUCTS AND MATERIALS

2.1 GENERAL

A. Location, text, and method of identification to be used is noted in individual sections. Refer to other sections for additional identification requirements.

2.2 NAMEPLATES

A. Engraved, Laminated Acrylic or Melamine Label: Non-conductive phenolic with beveled edges. 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. For elevated components, increase sizes of labels and letters to those appropriate for viewing from the floor.

1. Adhesive backed.
2. Minimum 1/16 inch (1.6 mm) thick for nameplates with either dimension greater than 4 inches (102 mm) and 1/8 inch (3.2 mm) thick for larger sizes.

B. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved or laser-etched text.

C. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text

D. Colors:

1. Normal systems - white letters on a black background.
2. Emergency systems - white letters on a red background.

2.3 LABELS FOR RACEWAYS AND METAL-CLAD CABLE

A. Factory Painted Raceways:

1. Metal Raceways: Continuous, rust-inhibiting paint factory applied.
2. Non-Metallic Raceways: Factory dyed or colored PVC sleeve.

B. Factory Painted Metal-Clad Cable: 2-inch wide, factory painted bands at a maximum of 6-foot on center spacing.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.4 LABELS FOR JUNCTION BOXES AND PULL BOXES

A. Junction box and pull box covers shall be spray painted to identify the voltage and system. Circuit numbers and the panel they originate from shall be listed on the cover using permanent, waterproof, black ink marker.

2.5 LABELS FOR WIRING DEVICES

A. Self-laminating Computer Printable Labels: Clear over-laminate to protect legend for permanent, clean identification. Self-laminating Polyester material with white print-on area.

2.6 MARKERS FOR CONDUCTOR AND CONTROL CABLES

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Self-laminating Computer Printable Labels: Clear over-laminate to protect legend for permanent, clean identification. Self-laminating Polyester material with white print-on area.

D. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- (0.35-mm-) thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

E. 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 nylon tie fastener.

2.7 TAGS

A. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.8 UNDERGROUND-LINE WARNING TAPE

A. Materials: Use foil-backed detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.

B. Foil-backed Detectable Type Tape: 6 inches (152 mm) wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.

C. Legend: Type of service, continuously repeated over full length of tape.

D. Color: Tape for Buried Power Lines: Black text on red background.

2.9 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145. Attachment method shall be acceptable to the manufacturers of the equipment to which the nameplates are being applied and shall not compromise any NRTL listing or labeling criteria.

B. Self-Adhesive Warning Labels: Factory pre-printed or machine-printed multicolor self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

1. Use thermal transfer process printing machines and accessories recommended by label manufacturer.
2. Do not use labels designed to be completed using handwritten text.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.

1. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.

1. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign 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 (208 Volts): "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
3. Workspace Clearance Warning (480 Volts): "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES (915 MM)."

2.10 ARC FLASH WARNING LABELS

A. General: All labels will be based on recommended overcurrent device settings and will be printed after the results of the analysis have been presented and after any system changes, upgrades, or modifications have been incorporated in the system. Refer to Division 26 section "Overcurrent Protective Device Study" for additional requirements.

B. Materials: Use machine-printed, high adhesion, polyester label; UV, chemical, water, heat, and abrasion resistant, for each work location analyzed.

C. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer. Labels shall be machine printed, with no field markings.

Provide warning labels complying with ANSI Z535.4 to identify arc flash hazards for each work location analyzed by the arc flash and shock risk assessment.

D. Minimum Size: 3.5 inch by 5 inch (89 mm by 127 mm), unless otherwise noted by Owner.

E. Legend: Provide custom legend in accordance with NFPA 70E based on equipment-specific data as determined by arc flash and shock risk assessment. The label shall include the following information, at a minimum:

1. Location designation
2. Nominal voltage
3. Available fault current
4. Limited approach boundary
5. Arc flash boundary
6. Restricted approach boundary
7. Hazard risk category
8. Incident energy
9. Working distance
10. Site-specific PPE (personnel protective equipment) requirements.
11. Date calculations were performed.
12. Engineering report number, revision number and issue date.

2.11 INSTRUCTION SIGNS

A. Engraved, Laminated Acrylic or Melamine plastic: Non-conductive phenolic. Unless indicated otherwise, provide with minimum 3/8-inch- (10-mm-) high letters. For elevated components, increase sizes of labels and letters to those appropriate for viewing from the floor.

1. Minimum 1/16 inch (1.6 mm) thick for nameplates with either dimension greater than 4 inches (102 mm) and 1/8 inch (3.2 mm) thick for larger sizes.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
4. Normal systems: Engraved legend with white letters on black face.
5. Essential Systems: Engraved legend with white letters on red face.

B. Stainless Steel Nameplates: Minimum thickness of 1/32 inch ; engraved or laser-etched text.

C. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text

D. Colors:

1. General Information and Operating Instructions – Black letters on white background.
2. Normal systems - white letters on a black background.
3. Emergency systems - white letters on a red background.

2.12 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength: 50 lb (22.6 kg), minimum.
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.

B. Fasteners for Nameplates, Labels and Signs

1. Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat lock washers unless otherwise noted.

2.13 PAINTED IDENTIFICATION

A. Paint materials and application requirements are specified in Division 09 painting Sections.

1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):

a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Exterior concrete and masonry primer.
2) Finish Coats: Exterior semi-gloss acrylic enamel.

2. Exterior Concrete Unit Masonry:

a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.

1) Block Filler: Concrete unit masonry block filler.
2) Finish Coats: Exterior semi-gloss acrylic enamel.

3. Exterior Ferrous Metal:

a. Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Exterior ferrous-metal primer.
2) Finish Coats: Exterior semi-gloss alkyd enamel.

4. Exterior Zinc-Coated Metal (Except Raceways):

a. Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Exterior zinc-coated metal primer.
2) Finish Coats: Exterior semi-gloss alkyd enamel.

5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):

a. Semi-gloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Interior concrete and masonry primer.
2) Finish Coats: Interior semi-gloss alkyd enamel.

6. Interior Concrete Unit Masonry:

a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.

1) Block Filler: Concrete unit masonry block filler.
2) Finish Coats: Interior semi-gloss acrylic enamel.

7. Interior Gypsum Board:

a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Interior gypsum board primer.
2) Finish Coats: Interior semi-gloss acrylic enamel.

8. Interior Ferrous Metal:

a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Interior ferrous-metal primer.
2) Finish Coats: Interior semi-gloss acrylic enamel.

9. Interior Zinc-Coated Metal (Except Raceways):

a. Semi-gloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.

1) Primer: Interior zinc-coated metal primer.
2) Finish Coats: Interior semi-gloss acrylic enamel.

PART 3 - EXECUTION

3.1 PREPARATION

A. Verify identity of each item before installing identification products.

B. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

C. Provide identification product listed for the location in which it is to be installed.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Painted Identification: Prepare surface and apply paint according to Division 09 painting sections.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. For surfaces that require finish work, apply identification devices after completing finish work. Do not install identification products until final surface finishes and painting are complete.

C. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed. Replace labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

D. Location: Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance without interference with operation and maintenance of equipment. Unless otherwise indicated, locate products as follows:

1. Surface-Mounted Equipment: Enclosure front.
2. Flush-Mounted Equipment: Inside of equipment door.
3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.

4. Elevated Equipment: Legible from the floor or working platform.
5. Branch Devices: Adjacent to device.
6. Interior Components: Legible from the point of access.
7. Conduits: Legible from the floor.
8. Boxes: Outside face of cover.
9. Conductors and Cables: Legible from the point of access.
10. Devices: Outside face of cover.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

1. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

G. Equipment Nameplates and Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual.

1. Indoor Clean, Dry Locations: Use plastic nameplates, unless noted otherwise.
2. Outdoor Locations: Use aluminum nameplates suitable for exterior use.

H. Install identification products centered, level, and parallel with lines of item being identified.

I. Mark all handwritten text, where permitted, to be neat and legible.

J. For refrigeration systems: Neatly bundle circuits and clearly tag and label each circuit with panelboard, branch circuit designation and refrigeration system number at each termination.

END OF SECTION

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes computer-based studies for the following:

1. Short-circuit analysis.
2. Protective device coordination study.
3. Arc flash and shock risk assessment, including arc flash hazard labels.

B. Criteria for selection and adjustment of equipment and associated protective devices not specified in this section, as determined by the studies performed.

1.2 ADMINISTRATIVE REQUIREMENTS

A. The AIC ratings indicated on the Drawings are preliminary and will be finalized based on the results of the short-circuit study. Device ratings for furnished equipment shall be as required by the results of the short-circuit study at no additional cost.

B. Coordination:

1. Existing Installations: Coordinate with equipment manufacturer(s) to obtain data necessary for completion of studies.
2. Coordinate the work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
3. Notify Contract Administrator of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

C. Pre-Study Meeting: Conduct meeting with Owner to discuss system operating modes and conditions to be considered in studies.

D. Sequencing:

1. Initial Study:

a. Study must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. Do not order equipment until matching study reports and product submittals have both been evaluated by the Contract Administrator.
b. If study has not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the Contractor at no additional cost to the project.

2. Final Study:

a. Study must be completed and submitted for review prior to substantial completion. Do not print arc flash labels until final study has been evaluated by the Contract Administrator.

b. Verify naming convention for equipment identification prior to creation of final drawings, reports, and arc flash hazard warning labels.

E. Scheduling:

1. Arrange access to existing facility for data collection with Owner.
2. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner. Refer to Division 26 section "General Electrical Requirements" for additional requirements.

1.3 SUBMITTALS

A. Product Data: In addition to submittal requirements specified in other sections, include manufacturer's standard catalog pages and data sheets for equipment and protective devices indicating information relevant to studies.

1. Product data for computer software program to be used for studies.
2. Include characteristic time-current trip curves for protective devices.
3. Include impedance data for busway.
4. Include impedance data for engine generators.
5. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
6. Include documentation of listed series ratings upon request.
7. Identify modifications made in accordance with studies to meet the results of the study.

B. Product Certificates: For coordination-study and short-circuit-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data:

1. Study Preparer Specialist qualifications.
2. Field Testing Agency qualifications.

D. Arc Flash Hazard Warning Label Samples: One of each type and legend specified.

E. Other Action Submittals:

1. Initial Study report, stamped or sealed and signed by study preparer, including:

a. Cover page including date of study, study methodology, assumptions made and software products used.
b. Study input data, including completed computer program input data sheets.
c. Short-circuit study report.
d. Equipment evaluation report.
e. Coordination-study report.
f. Settings report.

2. Final Study report, stamped or sealed and signed by study preparer, including:

a. Cover page including date of study, study methodology, assumptions made, software products used, and summary of changes between initial and final studies.
b. Study input data, including completed computer program input data sheets.
c. Short circuit study report.
d. Equipment evaluation report.

e. Coordination-study report.
f. Settings report.
g. Arc-Flash Hazard Analysis, including labels.

3. Certification that field adjustable protective devices have been set in accordance with requirements of studies.

F. Record Drawings: Submit Record Drawings as required by Division 01 and Division 26 Section "General Electrical Requirements":

1. Accurately record on the One-Line Diagram actual ratings and settings for all overcurrent devices, both adjustable and non-adjustable, including all changes made during construction, due to the study, or both.
2. Include computer software files used to prepare studies with file name(s) cross-referenced to specific pieces of equipment and systems.
3. Include copies of previous studies and existing drawings that were obtained during the data collection phase of the study.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Study Preparer Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state in which the Project is located, shall be responsible for the study and with a minimum five years experience in the preparation of studies of similar type and complexity using the specified computer software. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 399 for general study procedures.

D. Comply with IEEE 141, 242 and 551 for short-circuit currents and coordination time intervals.

E. Comply with IEEE 1584 and NFPA 70E for arc-flash hazard calculations.

F. Field Testing Agency Qualifications: Independent testing organization specializing in testing, analysis, and maintenance of electrical systems with minimum five years experience; NETA Accredited Company.

1. Field Supervisor: Certified electrical testing technician; NETA ETT Level III.

PART 2 - PRODUCTS AND MATERIALS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, use the latest commercially available computer software programs utilizing the specified methodologies developed by one of the following:

1. CYME International, Inc.
2. EDSA Micro Corporation.
3. Electrical Systems Analysis, Inc.
4. SKM Systems Analysis, Inc.
5. Operation Technology, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of short-circuit-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.

C. 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.

1. Zero-Sequence current.
2. Arcing faults.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

C. Short-circuit study and coordination study to be performed prior to the final submittals for any piece of electrical equipment which has an AIC rating or an over-current protective device so that correct equipment gets ordered for the project conditions.

D. Arc Flash Study must be performed after conductors and equipment have been installed and after the project's utility company confirms the available fault current. A final short-circuit and coordination study with all device settings shall be submitted with the Arc Flash Study. The goal of the revised settings is to minimize the arc flash hazard while maintaining reasonable coordination and selectivity. For the components of emergency and legally required standby system components, full selectivity must be maintained.

3.2 SYSTEM COMPONENTS TO BE INCLUDED IN STUDIES

A. Study shall begin with the utility and each alternate power source overcurrent device(s) serving the Project and end at the last branch circuit overcurrent protective device. This includes studies of the complete paths and operating modes on both sides of any transfer switch, contactor or circuit breaker.

B. Operating modes shall include, where applicable:

1. Utility as a source.
2. Bus tie breaker open/close positions.
3. Maintenance settings.

C. Components include, but are not limited to:
1. Switchboards
2. Distribution Panelboards
3. Panelboards
4. Air Handling Equipment
5. Roof Top HVAC equipment

3.3 POWER SYSTEM DATA FOR STUDIES

A. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling. Gather and tabulate the following input data to support studies:

1. Product Data for overcurrent protective devices specified in other Division 26 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. Impedance of utility service entrance.
3. Electrical distribution system diagram showing the following:

    a. Indicate load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
    b. Protective Devices: Include circuit-breaker and fuse-current ratings and types;
    c. Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio. kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    d. Cables: Indicate conduit material, sizes of conductors, conductor insulation, and length.
    e. Busways: Include bus material, ampacity and impedance.
    f. Motors: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 1 code letter designation.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    c. Ratings, types, and settings of utility company's overcurrent protective devices.
    d. Special overcurrent protective device settings or types stipulated by utility company.
    e. Protective Devices:

        1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).

2) Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).

f. Time-current-characteristic curves of devices indicated to be coordinated.
g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
i. Panelboards, switchboards, and interrupting ratings in amperes rms symmetrical.

5. Existing Installations:

a. Provide the services of field testing agency or equipment manufacturer's representative to perform field data collection.
b. Collect data on existing electrical distribution system necessary for completion of studies, including field verification of available existing data (e.g. construction documents, previous studies). Include actual settings for field-adjustable devices.

3.4 SHORT-CIRCUIT STUDY

A. Source Impedance: As an infinite bus on primary side of utility transformer.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operation modes that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Comply with IEEE 242 recommendations for fault currents and time intervals.

E. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
2. Low-Voltage Fuses: IEEE C37.46.
3. Circuit Breakers: IEEE C37.13.

F. Study Report:

1. Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report.
2. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault current values for 3-phase, 2-phase, and phase-to-ground faults.

G. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing short-circuit current ratings of these devices with calculated short-circuit current momentary and interrupting duties. Identify locations where the available fault current exceeds the equipment short circuit current rating, along with recommendations.

3.5 ARC-FLASH HAZARD ANALYSIS

A. Determine arc-flash incident energy levels and flash protection boundary distances based on the results of the Short-Circuit and Coordination studies in accordance with IEEE 1584. Perform the analysis under worst-case arc-flash conditions for all modes of operation.

B. In addition to the requirements outlined in IEEE 1584, the study shall include all equipment rated less than 240 Volts fed by transformers less than 125 kVA in the calculations.

1. Where reasonable, study preparer may assume a maximum clearing time of two seconds in accordance with IEEE 1584, provided that the conditions are such that a worker's egress from an arc flash event would not be inhibited.
2. For single-phase systems, the calculations may be performed assuming a three-phase system in accordance with IEEE 1584, yielding conservative results.

C. For equipment with main devices mounted in separate compartmentalized sections, perform calculations on both the line and load side of the main device.

D. Identify all locations and equipment to be included in the arc-flash hazard analysis:

1. Include a copy of the facility one-line in the report.
2. Identify the possible system operating modes including tie-breaker positions, and parallel generation.
3. Calculate the arcing fault current flowing through each branch for each fault location.
4. Determine the time required to clear the arcing fault current using the protective device settings and associated trip curves.
5. Select the working distances based on system voltage and equipment class.
6. Calculate the incident energy at each fault location at the prescribed working distance.
7. Determine the hazard/risk category (HRC) for the estimated incident energy.
8. Calculate the flash protection boundary at each fault location.
9. Document the assessment in reports and one-line diagrams.
10. Provide labels to be placed on each piece of equipment analyzed. Label shall show the calculated incident energy and hazard/risk category for the calculated incident energy.

E. Results of the arc-flash study shall be summarized in a final report containing the following:

1. Basis, method of hazard assessment, description, purpose, scope, and date of the study.
2. Tabulations of the data used to model the system components and a corresponding one-line diagram.
3. Descriptions of the modes of operation evaluated and identification of the worst case scenario used to evaluate equipment ratings.
4. Tabulations of equipment incident energies, hazard risk categories, and flash protection boundaries. The tabulation shall identify and clearly note equipment that exceeds allowable incident energy ratings.
5. Required arc-flash labeling and placement of labels.
6. Conclusions and recommendations, including recommendations for reducing incident energy at locations where calculated maximum incident energy exceeds 8 calories per sq cm.

3.6 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to set overcurrent protective devices within equipment.

1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

a. Verify that overcurrent protective devices meet parameters used in studies.
b. Adjust devices to values listed in final study results.
c. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 100.7 and 100.8 in NETA ATS.

3.7 INSTALLATION

A. Install arc flash warning labels. Refer to Division 26 section Identification for Electrical Systems for additional requirements.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect and test protective devices in accordance with the NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Overcurrent protection devices will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies protective device settings have been adjusted in accordance with the requirements of the study. Include notation of conflicts with or deviations made from the studies or the contract documents, deficiencies detected, remedial action taken, and observations after remedial action.

3.9 TRAINING

A. Provide training for Owner's personnel on electrical safety pertaining to arc flash and shock hazards.

B. Use site-specific arc flash and shock risk assessment report as training reference, supplemented with additional training materials as required.

C. Provide minimum of eight hours of training performed by a representative of the entity performing the study.

END OF SECTION

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following lighting control devices:
   1. Line-voltage wall switch occupancy sensors.
   2. Stand-Alone Low-voltage occupancy sensors.
   3. Stand-Alone Low-voltage photoelectric switches.
   4. Stand-Alone Low-voltage power packs.
   5. Stand-Alone Low-voltage switches.
   6. Conductors and Cables for Lighting Control Devices.

1.2 DEFINITIONS

A. Acoustic Type: Occupancy sensor detection type that detects occupancy by listening for acoustic noises.

B. Closed loop: Photosensor control algorithm designed for influence by both daylight and electric light in a space or area.

C. DPDT: Double pole, double throw.

D. DPST: Double pole, single throw.

E. Dual-Technology Type: Occupancy sensor detection type that detects occupancy by using a combination of PIR and ultrasonic or acoustic detection technologies.

F. LED: Light-emitting diode.

G. Open loop: Photosensor control algorithm designed for influence by daylight entering in a space or area.

H. PIR Type: Passive infrared. Occupancy sensor detection type that detects occupancy by sensing a combination of infrared heat and movement.

I. SPST: Single pole, single throw.

J. Ultrasonic Type: Occupancy sensor detection type that detects occupancy by sensing a change in pattern of reflected ultrasonic energy.

1.3 ADMINISTRATIVE REQUIREMENTS

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

1.4 SUBMITTALS

A. Product data for the following products:

1. Catalog cut sheets, including major and minor motion coverage patterns sensors, time delay and sensitivity adjustability settings, load restrictions, and performance specification items indicating compliance with this specification for all lighting control devices.

B. Shop Drawings:

1. Occupancy sensors and photoelectric switches

a. Show installation details.
b. Lighting plan showing location, mounting height, orientation and coverage area of each sensor and coordination with other trades.
c. Interconnection diagrams showing field-installed wiring.
d. Include diagrams for power, signal, and control wiring.
e. For any manufacturer submitted other than that listed as the Basis of Design, provide the following information for Engineer review:

1) Factory-generated occupancy sensor and photoelectric switch layouts on project lighting plans with sensor location, orientation and product type clearly marked on plans. Sensor placement shall be coordinated with project reflected ceiling plan layout, ceiling heights, lights, diffusers, and any other ceiling devices and equipment.
2) List of any deviations to this specification or Basis of Design products.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. Occupancy sensors and photoelectric switches:

a. Manufacturer's installation instructions, including instructions for storage, handling, protection, examination, preparation, start-up calibration and installation.
b. Product data clearly showing sensor field adjustments, including dip switch setting definitions and location of settings within sensors.
c. Manufacturer's maintenance, including operating and adjustment instructions.

1.5 QUALITY ASSURANCE

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

B. Occupancy sensors and photoelectric switches

1. Products supplied shall be from a single manufacturer that has been continuously involved in the manufacturing of occupancy sensors for a minimum of 5 years.
2. Products shall be manufactured by an ISO 9001 certified manufacturing facility.
3. Manufacturer shall test all equipment prior to shipment.

1.6 WARRANTY

A. Manufacturers shall provide a five (5) year warranty for sensors and accessories from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL INFORMATION

A. PIR type requirements:

1. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
2. Sensor shall utilize pulse count processing and digital signature analysis to respond only to those signals caused by human motion.
3. Sensor shall provide high immunity to false triggering from RFI and EMI.
4. Sensor shall have a multiple-segmented fresnel lens in a multiple-tier configuration, with grooves to eliminate dust and residue buildup. Sensor shall be capable of accepting mask inserts to mask specific portions of the lens to prevent false triggering.

B. Ultrasonic type requirements:

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection Frequency (Small Area – 500 sq ft and less): Ultrasonic operating frequency shall be crystal controlled at 40 kHZ within +/- 0.005% tolerance to assure reliable performance and eliminate sensor cross-talk.
3. Detection Frequency (Medium and Large Areas – greater than 500 sq ft): Ultrasonic operating frequency shall be crystal controlled at 32 kHz within +/- 0.005% tolerance, to assure reliable performance and eliminate sensor cross-talk.
4. Sensors shall be capable of automatically adapting to airflow conditions or filtering frequency spectrum related to air movement.

C. Dual-Technology type requirements:

1. Dual-Technology sensors using ultrasonic technology shall have field-selectable controls on unit to determine if a particular technology or combination of technologies controls the on-off function.
2. Dual-Technology sensors using acoustic technology shall have the PIR technology initially detect motion and a combination of PIR and acoustic technologies shall keep the load on.
3. Sensitivity Adjustment: Separate for each sensing technology.
4. Different LED indicator colors for each sensing technology
5. PIR sensor component shall comply with all requirements listed under PIR type requirements.
6. Ultrasonic sensor component shall comply with all requirements listed under Ultrasonic Type requirements.
7. Acoustic sensor component shall comply with all requirements listed under Acoustic Type requirements.

2.2 LINE VOLTAGE WALL SWITCH OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified in the Lighting Control Device Schedule on the Drawings and complying with all requirements listed.

B. General Requirements for Sensors:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C), unless indicated elsewhere for specific model and application.
3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.
4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply.

    a. Occupancy Sensor (auto-on): Upon occupancy of space, loads shall be energized. If occupancy is not detected within the time delay period, loads shall be de-energized.
    b. Vacancy Sensor (manual-on): Upon occupancy of space, loads are enabled such that manual operation of the switch shall energize loads. If occupancy is not detected within the time delay period, loads shall be de-energized.

5. Operation adjustment: Concealed, field-adjustable for auto-on or manual-on operation.
6. Time Delay adjustment:

    a. Concealed, field-adjustable.
    b. Time delay for de-energizing loads shall be adjustable with multiple increments from 30 seconds up to 30 minutes.

7. Adaptive technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
8. Mounting: Single-gang wall box switch
9. Finish: Sensor finish shall be as directed by the Architect.
10. Sensor:

    a. Vandal-resistant lens
    b. Integral sliding blinders or pre-cut tape strips to block sensor views
    c. Protrudes no greater than 0.50 inches from wall.
    d. 180-degree field of view
    e. Major and minor motion coverage patterns confirmed per Nema WD7 guidelines.
    f. Detection types: Provide type or types indicated in Lighting Control Device Schedule. Refer to Section 2.1 General Information above for more information.

11. Indicators:

    a. LED indicator for visual detection of motion
    b. audible and/or visual alerts for pending shut-off

12. Suitable for switching load types used, including LED, fluorescent, incandescent, magnetic and electronic low voltage and motor load types. UL listed and labeled, zero-cross relay, no minimum load requirement, ground wire.

13. Wall switch shall have no leakage of current to load and integral service switch to permit a maintained off for servicing of lamps for safety purposes
14. Buttons/Relays: Provide control relay and push button quantities as indicated by model listed in Lighting Control Device Schedule.
15. Restriction on leakage to grounding conductor.

    a. For new construction: Dual-technology wall switch sensor shall have not more than 0.5ma leakage of current to ground per UL requirements. Provide and connect a neutral conductor to these devices.

2.3 STAND-ALONE LOW-VOLTAGE OCCUPANCY/VACANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified in the Lighting Control Device Schedule on the Drawings and complying with all requirements listed.

B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensor unit, for use with a separate stand-alone low-voltage power pack containing a line-voltage relay.

1. Occupancy sensors and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Listed for dry locations and complies with local codes.
4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply.

    a. Occupancy Sensor (auto-on): Upon occupancy of space, loads shall be energized. If occupancy is not detected within the time delay period, loads shall be de-energized.
    b. Vacancy Sensor (manual-on): Upon occupancy of space, loads are enabled such that manual operation of a separate, associated switch shall energize loads. If occupancy is not detected within the time delay period, loads shall be de-energized.

5. Switch Rating: As indicated in Lighting Control Device Schedule.
6. Detection Coverage: As indicated in Lighting Control Device Schedule on Drawings.
7. Mounting: Suitable for mounting in any position on a standard outlet box.
8. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
9. Indicator: LED, to show when motion is detected during testing and normal operation of the sensor.
10. Bypass Switch: Override the "on" function in case of sensor failure, concealed on unit to prevent tampering.
11. Finish: Sensor finish shall be as directed by the Architect.
12. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.
13. Field selectable time delay and sensitivity settings or the capability for self-adjusting technologies to optimize time delay and sensitivity settings to respond to occupancy usage patterns. Occupancy usage patterns shall be saved in a non-volatile memory that retains settings in the event of a power outage.
14. Sensors:

    a. Sensor shall be compatible with lighting control system.

b. Sensors shall be capable of being combined with additional sensors to achieve adequate coverage.
c. Sensor coverage pattern: AS indicated on Lighting Control Device Schedule, and shall have been confirmed with Nema WD7 Guide and Robotic test method.
d. Detection types: Provide type or types indicated in Lighting Control Device Schedule. Refer to Section 2.1 General Information above for more information.

C. High-Bay Model:

1. Detection type: PIR type. Refer to Section 2.1 General Information above for more information.

2.4 STAND-ALONE LOW-VOLTAGE PHOTOELECTRIC SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified in the Lighting Control Device Schedule on the Drawings and complying with all requirements listed.

B. General Requirements for switches: Ceiling-mounted, solid-state indoor photoelectric switch, for use with a separate stand-alone low-voltage power pack, containing a line-voltage relay.

1. Switches and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Listed for dry locations and complies with local codes.
4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply. Upon ambient light level measurement reading below setpoint, loads shall be de-energized. Upon ambient light level measurement reading above setpoint, loads shall be energized.
5. Finish: Sensor finish shall be as directed by the Architect.

C. Outdoor:

1. Description: Solid state, low voltage with contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered as indicated on the Drawings.

a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
b. Time Delay: 30-second minimum, to prevent false operation.
c. Lightning Arrester: Air-gap type.
d. Mounting: Twist lock complying with IEEE C136.10, with base.

2.5 STAND-ALONE LOW-VOLTAGE POWER PACKS

A. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified in the Lighting Control Device Schedule on the Drawings and complying with all requirements listed.

B. General Requirements for power packs: Box mounted, solid-state indoor power pack/relay unit, for use with a separate stand-alone low-voltage sensor and switches.

1. Power packs and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Listed for dry locations and complies with local codes.
4. Unit shall include isolated relay with NO and NC contacts to interface with BMS, HVAC and or other building monitoring systems as indicated on the Drawings
5. Relay shall be compatible with the specific lighting types controlled.
6. Operations: Refer to drawings for Sequence of Operations or other operational instructions. Unit operates in conjunction with other system components. Refer to operations requirements of associated devices.
7. Switch Rating: As indicated in Lighting Control Device Schedule.
   Mounting: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
8. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.

2.6 STAND-ALONE LOW-VOLTAGE SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide either the named product or a comparable product by one of the other equivalent manufacturers specified in the Lighting Control Device Schedule on the Drawings and complying with all requirements listed.

B. General Requirements for switches: Wall-mounted, solid-state indoor manual switch, for use with a separate stand-alone low-voltage power pack, containing a line-voltage relay.

1. Switches and all other associated system components shall be provided by the same manufacturer and compatible with each other such that the final installation meets all operational and functional requirements in addition to those listed in this specification.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Listed for dry locations and complies with local codes.
4. Operations: Refer to drawings for Sequence of Operations or other operational instructions. If none appear on drawings, the follow shall apply. Manual push of any button shall energize or de-energize loads.
5. Mounting: Suitable for mounting in any position on a standard outlet box.
6. Indicator: LED, for each button to indicate when loads are energized and de-energized.
7. Finish: Sensor finish shall be as directed by the Architect.
8. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.

2.7 CONDUCTORS AND CABLES FOR LIGHTING CONROL DEVICES

A. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables.

B. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG.

C. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG.

D. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG.

E. Provide all necessary conductor and cabling required for operation of the controls and control systems specified. This includes power and control wiring required for the controls to operate as described.

PART 3 - EXECUTION

3.1 INSTALLATION

A. GENERAL

1. Install devices and associated power packs and wiring in accordance with manufacturer's instructions and applicable codes.

B. LINE VOLTAGE WALL SWITCHES

1. Install dimming wall switches to achieve full rating specified on Lighting Control Device Schedule taking into account de-rating for ganging as instructed by the manufacturer.
2. Provide a separate grounded (neutral) conductor for each circuit controlled by a line voltage switch.

    a. Do not share neutral conductor on load side of dimmers.
    b. If neutral termination is not required for the device, cap conductor and tag as "Neutral for future use".

C. OCCUPANCY/VACANCY SENSORS AND PHOTOELECTRIC SWITCHES

1. Arrange a pre-installation meeting with manufacturer's factory authorized field representative, at Owner's facility, to verify placement of sensors and installation criteria.
2. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage areas specified in manufacturer's literature. The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms or areas that are to be provided with sensors. Provide additional sensors as required to properly and completely cover the respective areas.
3. 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.
4. Occupancy sensors with ultrasonic or dual-technology sensing technologies shall be located not closer than 4 feet from the nearest edge of air supply devices or similar obstructions that would adversely affect the sensor performance.
5. Adjust time delay setting of occupancy sensors to de-energize loads after space has been unoccupied for period of time indicated on the Drawings.
6. Install outdoor photoelectric switches with clear view of the northern sky unless noted otherwise on the Drawings.
7. Adjust settings of photoelectric switches to turn on lighting at illumination level indicated on the Drawings.
8. Install devices and auxiliary equipment in compliance with manufacturer's instructions and recommendations.
9. Install relay units where concealed from view and where accessible.

10. 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.
11. Install switchbox mounted occupancy sensors at same elevation as other lighting control switches.

D. WIRING

1. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
2. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
4. 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. General: Provide identification complying with requirements specified in Division 26 Section "Identification for Electrical Systems."

B. Power and control wiring: Identify using marker tapes.

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric switches and occupancy sensors at each sensor.

C. Components: Label each component with self-laminating computer printed labels, using a unique designation matching control drawing.

D. Cover plates: Refer to drawings for labeling requirements of certain cover plates for manual switches, or similar devices, requiring labeling for user information.

E. Buttons/switches:

1. Engraved from manufacturer. Refer to drawings for detailed requirements and text for labeling.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Test all occupancy sensors in test mode to confirm sensor coverage and sensitivity of sensor per manufacturer's instructions. Upon completion of tests, set sensor time delay as indicated on Lighting Control Device Schedule. Follow testing and adjustment procedures as written in the manufacturer's installation instructions for each sensor model.

B. Lighting control devices that fail tests and inspections are defective work. Remove, replace, and retest devices that fail tests.

3.4 ADJUSTING

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

B. Photoelectric switch Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project for this purpose.

3.5 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Lighting Control Systems."

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training" and Division 26 Section "Lighting Control Systems" for additional information.

END OF SECTION

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1500 kVA:

1. Distribution transformers.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, technical certification sheets and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Transformer ratings including:

a. kVA
b. Primary and secondary voltage
c. Taps
d. Basic impulse level (BIL) for equipment over 600 volts
e. Design impedance
f. Insulation class and temperature rise
g. Sound level.

C. Qualification Data: For testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

E. Transformers shall meet the requirements of the most current version of federal law 10 CFR Part 431 "Energy Efficiency Program for Certain Commercial and Industrial Equipment".

F. All transformers shall be UL listed and bear the UL label.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Hammond Company
5. Sola/Hevi-Duty
6. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: One leg per phase. Cores shall be constructed of high grade, non-aging silicon steel. The core and coil assembly shall be impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The completed core and coil shall be bolted to

the base of the enclosure but isolated by means of rubber, vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor or strap sized in accordance with UL and NEC requirements. The neutral shall be brought to a stud to facilitate the required external grounding of the secondary

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum.

D. Connections to transformers shall be by flexible metal conduit and using flexible couplings.

E. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.

F. Wiring/Terminations:

1. Recommended external cable shall be rated 90 degrees C (sized at 75 degrees C ampacity) for encapsulated and 75 degrees C for ventilated designs.
2. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.
3. Lug kits shall be provided by the Manufacturer of the transformer.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Enclosures: Unless otherwise specified, transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. Enclosures shall have a baked polyester powder coat finish-gray in color and suitable for interior or exterior applications. Enclosures shall be constructed so that there are no exposed live parts. Enclosures shall have a removable front cover to allow access to internal parts and wiring terminations

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
2. Transformer locations:

a. Dry locations:

1) Ventilated
2) NEMA 250, Type 2.

b. Damp or wet:

1) Ventilated. Provide weather shields over ventilation openings.
2) NEMA 250, Type 3R.

c. Corrosive locations:

1) Totally enclosed, non-ventilated
2) NEMA 250, Type 4X, stainless steel

3. The maximum temperature of the enclosure shall not exceed 90 degrees C.

4. The maximum temperature of the top of the enclosure shall not exceed 50°C rise above a 40°C ambient.

C. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: ANSI 61 gray.

D. Taps
1. Transformers 25 kVA through 500 kVA:

a. Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

E. Insulation Class for transformers less than 15 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

F. Insulation Class for transformers 15 kVA and larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature

G. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with the requirements of the most current version of federal law 10 CFR Part 431 "Energy Efficiency Program for Certain Commercial and Industrial Equipment" efficiency levels.
2. Tested in accordance with federal law 10 CFR Part 431.

H. Mounting Methods.

1. Transformers 75 KVA and larger shall be floor mounted unless indicated otherwise. Transformers 45 KVA and smaller may be wall mounted where wall construction is suitable for the load. Floor mounted transformers shall be securely bolted to a 4 inch, concrete housekeeping pad with vibration isolation pads. Wall mounted or suspended transformers shall have a means of isolating vibration from the support.
2. Transformers up through 1000 KVA shall be mounted on elastomeric vibration isolation pads. Pad shall be constructed of neoprene, rubber, glass fiber, or a combination thereof. Pads shall be "ribbed" or "waffled" in texture. Pads shall be selected for smallest durometer (hardness), preferably less than 50. Deflection of pad shall be .25" static minimum. Stack pads until the desired deflection is achieved.
3. Wall Mounting: Manufacturer's standard brackets.
4. Suspended Mounting: See transformer mounting detail on plans.

I. Low-Sound-Level Requirements: Maximum sound levels (NEMA ST 20), when factory tested according to IEEE C57.12.91, as follows:
1. 51 to 150 kVA: 50 dBA

2.4 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to ANSI C57.12.01 and IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

2.5 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. Ratio tests at the rated voltage connection and at all tap connections
2. Polarity and phase relation tests on the rated voltage connection
3. Applied potential tests
4. Induced potential test
5. No-load and excitation current at rated voltage on the rated voltage connection

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Floor mounted transformers shall be mounted on a 4 inch concrete housekeeping pad 2 inches larger all around transformer.

C. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

D. Use flexible conduit under the provisions of Division 26 Section "Raceways and Boxes for Electrical Systems" for connections to transformer case. Minimum flexible conduit length shall be two (2) feet.

E. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

F. CONNECTIONS

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

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

3.3 IDENTIFICATION

A. Nameplates: Label each transformer with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems." Nameplates shall be engraved with the following information

1. Transformer name
2. Fed from (primary source)
3. Secondary voltage, phase, wires

B. Warning Labels: Label each panelboard with a warning label indicating NFPA 70 workspace clearance requirements, complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 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. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES:

A. Distribution panelboards.

B. Lighting and appliance branch-circuit panelboards.

C. Disconnecting and Overcurrent Protective Devices.

D. Surge Protection Devices.

E. Accessory Components and Features.

1.2 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. SPD: Surge Protection Device

1.3 ADMINISTRATIVE REQUIREMENTS

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. Coordinate sizes and locations of concrete bases with actual equipment provided. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit electronic files, in an SKM-compatible format.

C. Fault-Current Study, Coordination Study, and Overcurrent Protective Device Settings report must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. If studies have not been approved prior to shipping, assembly or final ordering of the electrical distribution system components, all changes to the equipment necessitated by the results of the study will be provided by the contractor at no additional cost to the project. Refer to specification section "Overcurrent Protective Device Coordination Study"

D. Qualification Data: For qualified testing agency.

E. 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.

F. Panelboard Schedules: Submit final panelboard directories.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for panelboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

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. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

1.6 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 NEMA PB 1.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to occupied facilities. Refer to Division 26 Section "General Electrical Requirements" for allowable outages.

1.8 WARRANTY

A. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Enclosures: Flush- or surface-mounted cabinets as noted.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

2. Hinged Front Cover: Entire front trim hinged to box.
3. Door: Standard door with concealed hinges, within hinged trim cover. Secured with vault-type latch with tumbler lock; keyed alike.
4. Finishes:

a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized steel.

5. Directory Card: Inside panelboard door, mounted in transparent card holder.

C. Incoming Mains Location: Top and/or bottom as required.

D. Buses: Three phase, four wire unless otherwise indicated.

1. Phase, and Neutral Buses:

a. Material:

1) Tin-plated aluminum.

a) Hard-drawn copper, 98 percent conductivity, may be substituted if provided at no additional cost.

b. Size: Ampacity as indicated on drawings, with uniform capacity for entire length of panelboard's sections.

1) Neutral bus: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus

2. Ground Bus: Equipped with connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

a. Material: Hard-drawn copper, 98 percent conductivity
b. Size: Minimum-size required by UL 67

E. Line-Side Conductor Connectors (Lugs):

1. General: Suitable for use with conductor material and sizes. Connections shall comply with requirements of Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
2. Material: Same as bus material.
3. Capacity rating: Same as associated bus.
4. Type: Provide mechanical type.

F. Feed-Through Lugs:

1. General: Suitable for use with conductor material and sizes. Connections shall comply with requirements of Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
2. Location: Locate at opposite end of bus from line side lugs or main device.
3. Material: Same as line side conductor connectors.
4. Capacity rating: Same as associated bus.
5. Type: Same as line side conductor connectors.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating – Fully Rated: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

A. See manufacturers above.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

D. Mains: As indicated on drawings.

E. Branch Overcurrent Protective Devices:

1. Connection to bus:

a. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

b. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2. Type: Provide types as indicated on drawings and as defined below.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. See manufacturers above.

B. Panelboards: Circuit breaker type: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: As indicated on drawings.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. See manufacturers above.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical type unless otherwise indicated on Drawings, suitable for number, size, trip ratings, and conductor materials.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

        1) Mounting: Integral

e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
f. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
g. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
h. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

D. Fuses are specified in Division 26 Section "Fuses."

2.5 SURGE PROTECTION DEVICES

A. Provide surge protective devices as required by Division 26 Section "Surge Protective Devices".

B. Panelboards requiring SPD and the location of the devices shall be as indicated on the Drawings.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Wall-Mounted Panelboards: Install panelboards on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For panelboards not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Mount top of trim 72 inches (1788 mm) above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

F. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

G. Install filler plates in unused spaces.

H. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.

I. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

J. Comply with NECA 1.

3.3 IDENTIFICATION

A. General: Provide identification complying with requirements specified in Division 26 Section "Identification for Electrical Systems."

B. Panelboard Nameplates: Label each panelboard with a nameplate.

C. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate.

D. Warning Labels: Label each panelboard with a warning label in accordance with NFPA 70 and NFPA 70E.

1. Exception: Do not install NFPA 70 working clearance requirements on flush panelboards and similar equipment in finished spaces.

E. Identify field-installed conductors, interconnecting wiring, and components; complying with Division 26 Section "Identification for Electrical Systems."

F. Panel Directories

1. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
2. Noted the date the directory was created/updated.
3. Create directory after loads have been balanced.
4. Replace existing directories with revised type written directories indicating changes.

3.4 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Receptacles: Duplex, double duplex, twist-lock, ground-fault circuit interrupters (GFCI), and tamper resistant (TR).
2. AC Wall Switches: Single- and double-pole, three- and four-way, maintained and momentary, pilot light and lighted toggle.
3. Device Wall Plates.
4. Multi-Outlet Assemblies.

1.2 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. IG: Isolated Ground

C. PIR: Passive Infrared.

D. RFI: Radio Frequency Interference

E. SPD: Surge Protective Device

F. USB: Universal Serial Bus

G. TR: Tamper Resistant

1.3 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements".

B. Product data for the following products:

1. Provide manufacturer's catalog information specifically marked to indicate which devices are being furnished, and showing dimensions, colors, and configurations for all devices, including, but not limited to: Receptacles, AC wall switches, cover plates, power poles, and multi-outlet assemblies.

C. Field quality-control test reports.

D. Operations and Maintenance Data:

E. Warranty: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated cover plate from a single manufacturer and through one source. Where practical and possible, obtain all wiring devices and associated cover plates from a single manufacturer and one source.

B. Materials shall be manufactured by companies that have been specializing in the products specified in this Section, for a minimum of 10 years.

C. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that are acceptable to authorities having jurisdiction.
2. Marked for intended use.

D. Comply with NFPA 70.

1.5 COORDINATION

A. Receptacles for Equipment Furnished by Owner or Under Other Divisions or Contracts: Match plug configurations.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Wall Plates: One for every 10 of each type (i.e., style, size, and finish) installed, but no fewer than two of each type.

PART 2 - PRODUCTS AND MATERIALS

2.1 GENERAL

A. Wiring devices are defined as single discrete units of electrical distribution systems, such as convenience receptacles, switches, special purpose receptacles, and similar, which are intended to carry, but not use electrical energy. Install wiring devices as required by the Specifications and where indicated on the Drawings.

2.2 MANUFACTURERS

A. Manufacturers:

1. Receptacles and Switches:

a. Eaton.
b. Hubbell Incorporated.
c. Legrand.
d. Leviton.

2. Multioutlet Assemblies:

   a. Hubbell Incorporated.
   b. Legrand.

B. In other Part 2 articles below, where manufacturers and device catalog numbers are included, the following additional requirements apply to product selection:

1. Product manufacturer and model numbers listed are to establish the quality of the wiring devices. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include manufacturers listed in individual articles below, in addition to those listed in Paragraph "Manufacturers" above.
2. Coordinate the proper suffixes in order to provide the correct color as specified below.

2.3 FINISHES

A. Color:

1. Wiring devices connected to normal power systems: As selected by Architect unless otherwise indicated or required by NFPA 70. Cover plates: The same as the wiring device.

2.4 CONVENIENCE RECEPTACLES

A. The catalog numbers listed below are generally for 20A rated devices. Where 15A rated devices are indicated on the Drawings or required for circuit rating limitations, provide receptacles equivalent to those specified for 20A, but rated for 15A.

B. Duplex convenience receptacles: Heavy Duty Specification grade, NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, smooth nylon face, side and back wired, self-grounding.
   Basis of Design: Legrand 5362 duplex.

C. Duplex tamper resistant convenience receptacles: Heavy Duty Specification grade, NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, smooth nylon face, side and back wired, self-grounding.
   Basis of Design: Legrand TR5362.

D. Duplex weather resistant convenience receptacles: Heavy Duty Specification grade, NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, smooth nylon face, side and back wired, self-grounding.
   Basis of Design: Legrand WR5862.

E. Twist-Locking type receptacles: NEMA L5-20R, 125V, 20A, grounding type, UL listed and labeled, nylon face, side and back wired, self-grounding.
   Basis of Design: Legrand L520-R.

2.5 GFCI RECEPTACLES

A. Ground fault circuit interrupter type receptacles: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025

second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Basis of Design: Legrand 2097

B. Ground fault circuit interrupter type weather-resistant receptacles: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Basis of Design: Legrand 2097TRWR

C. Ground fault circuit interrupter type tamper and weather-resistant receptacles: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Basis of Design: Legrand 2097TRWR

D. Ground fault circuit interrupter with Blank Face: Specification Grade UL listed and labeled complying with UL 943, Class A and NEMA WD-1-1.10, 125V, 20A, trip at 4-6mA within 0.025 second, and feed-thru type with integral heavy duty NEMA 5-20R receptacle arranged to protect receptacles down stream on the same circuit.

Basis of Design: Legrand 2085.

2.6 SWITCHES

A. The catalog numbers listed below are generally for 20A rated devices. Where 15A rated devices are indicated on the Drawings or required for circuit rating limitations, provide switches equivalent to those specified for 20A, but rated for 15A.

B. Switches: Heavy Duty Specification grade, rated for 120/277V, 20A, back and side wired, and UL listed and labeled.

Basis of Design: Legrand.
1 pole PS20AC1

C. Key operated light switches: Same as standard light switches except toggle handle shall be operated by a factory provided key.

Basis of Design: Legrand.
1 pole PS20AC1-L

2.7 MULTI-OUTLET ASSEMBLIES

A. Surface type strips: Extruded aluminum 3-wire, single circuit with single grounding type, 15A, 125V receptacles, pre-wired on 12-inch centers. Provide all fittings, devices, end closures, elbows, boxes and conduit entrance fittings as required for a complete installation.

Basis of Design: Legrand ALA4800.

2.8 COVER PLATES

A. Wet Location Weatherproof Receptacle Cover Plates (Outlet Box Hood): NEMA 3R weather resistant recessed or flush mount, die cast aluminum lockable cover. Configure cover for horizontal mounting of receptacle or as indicated otherwise. Back box must be suitable for conduit connections. Coordinate back box with wall depth.
Basis of Design: Leviton IUM1H-GY.

A. Other locations: Single and combination types to match corresponding wiring devices and manufacturer of wiring devices specified herein.

1. Plate securing screws: Metal with head color to match finish plate.
2. Material for Finished Spaces: Brushed stainless steel Type 302.
3. Material for Unfinished Spaces and surface mounted wiring devices: Galvanized steel.
4. Masonry walls and oversized wall openings: Jumbo size plates with same material as indicated above.

PART 3 - EXECUTION

3.1 GENERAL

A. Outlets are only approximately located on the small scale Drawings. Use great care in the actual location by consulting the various large scale detailed Drawings used by other Division trades, and by securing definite locations from the Contract Administrator.

B. Do not use multi-conductor circuits, with a shared neutral, for any GFCI receptacle circuit. Provide a separate neutral conductor with all GFCI receptacle circuits.

C. Provide twist-locking type receptacles or other special type receptacles where indicated on the Drawings.

3.2 EXAMINATION

A. Verify existing conditions prior to beginning work.

B. Verify that outlet boxes are installed at proper height and are flush with the finished surface.

C. Verify that wall openings are neatly cut and will be completely covered by wall plates.

D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.3 PREPARATION

A. If required, provide extension rings to bring outlet boxes flush with finished surface.

B. Clean debris from in and around outlet boxes.

3.4 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install all wiring devices plumb, level, and square with building lines. Wiring device bodies shall extend to the finished surface of the walls, ceiling or floor, as applicable, without projecting beyond them.

C. Connect wiring devices by wrapping conductors around screw terminals. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

D. Connect wiring device grounding terminal to branch circuit equipment grounding conductor and bond to metal outlet box. Exception: Do not bond grounding terminals of isolated ground receptacles to the outlet box.

E. Install devices shown on wood trim, cases or other fixtures symmetrically and, where necessary, set with the long dimensions of the plate horizontal, or ganged in tandem.

F. Unless dimensioned otherwise, install wiring devices a minimum of 24 inches from the closest edge of any sink.

G. Install switches with OFF position down.

H. Install cover plates on all switches, receptacles, and blank outlets.

I. Locate wiring devices so that the cover plate does not have to be cut to be installed.

J. Where devices are shown near wall openings, coordinate location if corner guards are to be installed so that cover plates do not require cutting.

K. Install cover plates after the wall has been finished (painted, wall paper, etc).

L. Install device boxes in brick or block walls such that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

M. Provide engraved nameplate on emergency off buttons.

N. Provide ground fault circuit interruption capability for all 120V receptacles 50A or less and all 208/240V receptacles 100A or less in code required locations. Locations include, but are not limited to: bathrooms, kitchens/food prep areas, exterior locations and within 6' or sinks. Interruption capability can be achieved via a GFCI circuit breaker or a GFCI receptacle.

O. Provide type and quantity of normally open and/or normally closed contacts for emergency off buttons to meet the sequence of operations shown.

P. Install wiring devices shown back-to-back on a common wall offset a minimum of 12" horizontally to reduce sound transmission between rooms.

Q. Provide safety-type, tamper-resistant receptacles in all areas where receptacles are mounted less than 5'-6" AFF and are easily accessible to children.

3.5 MOUNTING HEIGHTS

A. Coordinate locations of outlet boxes provided under Division 26 Section "Common Work Results for Electrical".

B. Unless noted otherwise, install wiring devices at mounting heights indicated in the Electrical Symbols Legend on the construction drawings.

1. Receptacles:

a. General:

1) Unless indicated otherwise, install vertically with the ground slot mounted at the top.
2) Where Installed horizontally, install neutral slot mounted at the top.

b. Above counters:

1) Mount vertically.

c. Mechanical and electrical equipment rooms and janitors closets:

1) Mount horizontally.

d. Weatherproof exterior receptacles:

1) Mount horizontally.

e. GFCI receptacles: Same as general receptacles.
f. Concrete Block Walls: Dimensions above may be adjusted slightly, as required to compensate for variable joint dimensions, such that bottom or top of boxes, as applicable, are at block joints.

2. Switches:

a. Above counters: Same as for receptacles.
b. Concrete Block Walls: Dimension may be adjusted slightly, as required to compensate for variable joint dimensions, such that bottom of boxes are at block joints.
c. Walls with wainscoting: 6 inches minimum above wainscoting, but not exceeding 48 inches above finished floor.

3. Multi-outlet assemblies:

a. As indicated on the Drawings.

4. Telephone/Data Outlet Boxes:

a. General: Match mounting height of adjacent wiring device listed above.

3.6 IDENTIFICATION

A. Label all devices fed down stream of GFCI protected receptacles as "GFCI PROTECTED".

B. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles and Switches: Identify panelboard and circuit number from which served, using:
   a. Adhesive film label, but with letter/number height of 1/4 inch, on face of plate.
   b. Adhesive Film Label with Clear Protective Overlay, but with letter/number height of 1/4 inch, on face of plate, for exterior and damp/wet locations.

3.7 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify that each receptacle device is energized. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.

D. Test all wiring devices for electrical continuity and proper polarity of connections.

E. Test each GFCI receptacle device for proper operation.

F. Correct wiring devices incorrectly installed.

G. Repair or replace all damaged items or damaged finishes at no expense to the Owner.

3.8 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.9 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in:
   a. Enclosed switches
   b. Switchboards

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses 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. All items requested under "Product Data".

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

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. Comply with UL 248.

1.4 PROJECT 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.

1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

B. Coordinate location of and access to spare fuse cabinet(s) with final electrical equipment layouts within electrical equipment rooms.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.

C. Provide fuses of the same type, rating, and manufacturer within the same switch.

D. Selectivity: Where selectivity is required by the Documents, furnish products as required to achieve selective coordination.

2.2 MANUFACTURERS

A. Manufacturers:

1. ABB Ltd.
2. Eaton Corporation Plc
3. Mersen Electrical Power
4. Littelfuse, Inc.
5. Schneider Electric SE
6. Siemens AG

2.3 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.4 ACCESSORIES

A. Provide the following accessories where indicated or where required to complete installation:

1. Fuseholders: Compatible with indicated fuses.
2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.
3. Plug-Fuse Adapters: For using Type S, rejection-base plug fuses in Edison-base fuseholers or sockets; ampere ratings matching fuse ratings; irremovable once installed.

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 INSTALLATION

A. Do not install fuses until circuits are ready to be energized.

B. Install in accordance with manufacturer's instructions.

C. Install fuses in fusible devices. Arrange fuses so manufacturer, type and rating information is readable without removing fuse.

D. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.

E. Install spare-fuse cabinet(s).

3.3 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance:
   a. 600A or less:

1) Class RK1, time delay

2. Feeders:
   a. 600A or less:

      1) Class RK1, time delay

3. Motor Branch Circuits:

   a. Class RK1, time delay

4. Other Branch Circuits:

   a. Class RK1, time delay

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 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.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).

4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Qualification Data: For qualified testing agency.

C. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

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. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than 7 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.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, 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. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.

5. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240-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.

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. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

F. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

G. 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. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
4. 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.

2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.

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.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

END OF SECTION

SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual:

a. Fractional Horsepower Manual Controllers:

1.2 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than 7 days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical systems without Owner's written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 GENERAL

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

1. Eaton Electrical Inc.: Cutler-Hammer Business Unit.
2. General Electric Company: GE Consumer & Industrial - Electrical Distribution.
3. Rockwell Automation, Inc.: Allen-Bradley brand.
4. Siemens Energy & Automation, Inc:
5. Square D: a brand of Schneider Electric.

B. Mounting: Controllers may be surface mounted in equipment rooms and unfinished spaces but shall be flush mounted in finished spaces or where noted on the Drawings.

2.2 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Manual Motor Starter Disconnect Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Configuration - Configuration of individual controller is noted on the Drawings.

a. Red pilot light:

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Configuration: Nonreversing.
2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
3. Surface mounting.
4. Red pilot light:

2.3 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.

2.4 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Comply with NECA 1.

3.2 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

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

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient

motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes requirements for UL 96A Master Labeled lightning protection system consisting of air terminals on roofs, roof mounted mechanical equipment, stacks, bonding of structure and miscellaneous metal objects; Grounding electrodes; and interconnecting conductors.

B. System Design: Contractor shall perform all calculations and develop all plan and detail drawings required, in conjunction with these specifications, for installation of a complete and fully functional lightning protection system.

1.2 CODES, REFERENCES AND STANDARDS

A. Applicable Codes and Standards

1. NFPA 70 – National Electrical Code
2. UL 96 – Lightning Protection Components
3. UL 96A – Installation requirements for Lightning Protection Systems
4. NFPA 780 – Lightning Protection Systems

1.3 DEFINITIONS

A. The following definitions apply to terms used in this section:

1. Air Terminal: A strike termination device that is a receptor for attachment of flashes to the lightning protection system and is UL listed for that purpose.
2. Bonding: An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.
3. Class I Materials: Lightning conductors, air terminals, ground terminals, and associated fittings required by NFPA 780 for protection of structures not exceeding 75 feet (23 meters) in height.
4. Class II Materials: Lightning conductors, air terminals, ground terminals, and associated fittings required by NFPA 780 for the protection of structures exceeding 75 feet (23 meters) in height.
5. Bonding conductor: A conductor intended to be used for equalization between grounded metal bodies and a lightning protection system.
6. Main conductor: A conductor intended to be used to carry lightning currents between strike termination devices (air terminals) and ground terminals.
7. UL: Underwriters Laboratories, Inc.
8. LPI: Lightning Protection Institute

1.4 SUBMITTALS

A. Product Data: Submit product data showing dimensions and materials of each component including listing in accordance with UL 96A.

B. Shop Drawings: For air terminals and mounting accessories.

1. Layout of the lightning protection system showing layout of air terminals grounding electrodes, and bonding connections, along with details of the components to be used in the installation.
2. Include indications for use of raceway, conductor sizes, roof and/or floor penetrations, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
3. Layout and installation drawings shall be fully coordinated with other trades. Failure of the lightning protection contractor to perform this coordination shall not relieve said contractor from properly completing the work.

C. Qualification Data: For qualified manufacturer. Include data on listing or certification by UL.

1. Manufacturer: A company specializing in lightning protection equipment with minimum 3 years documented experience and membership in good standing with the Lightning Protection Institute.

D. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.

E. Field quality-control reports.

F. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.

G. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:

1. Ground rods.
2. Ground loop conductor.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Certified by UL trained and approved for installation of units required for this Project.
2. The contractor shall be recognized as being regularly engaged in the design and installation of lightning protection systems with a minimum of 3 years documented experience.
3. Include documentation of certification and experience with all submitted bids.

B. System Certificate:

1. UL Master Label.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. All materials used in the installation shall be new and shall comply in weight, size, and composition with UL 96 and NFPA 780. Materials shall be labeled or listed by UL for use on lightning protection systems.

B. Roof-Mounted Air Terminals: NFPA 780, Class I aluminum unless otherwise indicated.
1. Manufacturers:
    a. East Coast Lightning Equipment Inc.
    b. ERICO International Corporation.
    c. Harger.
    d. Heary Bros. Lightning Protection Co. Inc.
    e. Independent Protection Co.
    f. Preferred Lightning Protection.
    g. Robbins Lightning, Inc.
    h. Thompson Lightning Protection, Inc.
2. Air Terminals More than 24 Inches (600 mm) Long: With brace attached to the terminal at not less than half the height of the terminal.
3. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 07 roofing Sections.

C. Main and Bonding Conductors: Copper and Class I.

D. Ground Rods: Copper-clad steel; 3/4 inch (19 mm) in diameter by 10 feet (3 m).

2.2 SURGE PROECTIVE DEVICES

A. Surge Protective Devices SPD's required to meet UL 96A for UL Master Labeling shall be as specified in Division 26 Section "Surge Protective Devices".

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install lightning protection components and systems according to UL 96A and NFPA 780.

C. Install conductors with two direct paths from air terminals to ground connections. Avoid sharp bends. Follow the manufacturer's written installation instructions.

D. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view of exterior locations at grade within 200 feet (60 m) of building.

E. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

F. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

G. Air Terminals on Mechanical Equipment: Air terminals on mechanical equipment shall be mounted such that maintenance operations can be performed without relocation of the air terminal or interconnecting conductors.

3.2 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

A. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

B. UL Inspection: Meet requirements to obtain a UL Master Label for system.

END OF SECTION

SECTION 264313 - SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Section includes Surge Protection for:
   1. Panelboard Suppressors Internally Mounted In Panelboards

B. Section includes field-mounted SURGE Protective Devices (SPD's) for low-voltage (120 to 600 V) power distribution and control equipment. Device type ratings shall be:
   1. Type 2 - Service entrances or distribution switchboards or panelboards

C. Refer to Definitions below for clarification of type selection.

1.2 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. VPR: Voltage Protection Rating. The average of measured limiting voltage before and after Nominal Discharge Testing (In),) rounded up to one of UL's VPR categories (Table 63.1 of ANSI/UL 1449 Current Edition) such as 330 volt, 400 volt, 500 volt, etc. VPR is posted on each device UL label.

C. In or In or Inominal: Nominal Discharge Current. Peak value of surge current, selected by the manufacturer, through the SPD having current wave shape of 8/20 microseconds where the SPD remains functional after 15 surges. In is posted on the device UL label.

D. SPD: Surge Protective Device. Previously Transient Voltage Surge Suppressor (TVSS), a broad class of protective devices, installed parallel with the distribution panel or service disconnect, meant to protect downstream electrical distribution equipment from the effects of high voltage surges on the line.

E. MCOV: Maximum Continuous Operating Voltage. The maximum continuous operating voltage rating of a Metal Oxide Varistor (MOV) that can be applied without the MOV being damaged and/or destroyed by thermal runaway. MCOV is posted on the device UL label.

F. SCCR: Short Circuit Current Rating. The maximum current rating the SPD can sustain without being damaged and/or destroyed. SCCR is posted on the device UL label.

G. SPD Type:
   1. TYPE 2: Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device, including SPDs located at the branch circuit panel.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordinate SPD devices with Division 26 Section "Electrical Power Monitoring and Control."

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include model number, SPD type, system voltage, phases, modes of protection, voltage Protection rating (VPR), and Nominal Discharge Current (I_n), and accessories required.

B. Qualification Data: For qualified testing agency.

C. Product Certificates: For SPD devices, from manufacturer.

D. Field quality-control reports.

E. Operation and Maintenance Data: For SPD devices to include in emergency, operation, and maintenance manuals.

F. Warranties: Sample of special warranties.

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 by UL or other Nationally Recognized Testing Laboratory (NRTL) as defined in NFPA 70, by a testing agency, and marked for intended location and application.

C. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

D. Comply with NEMA LS 1.

E. Comply with UL 1283 and ANSI/ UL 1449 Current Edition.

F. Comply with NFPA 70.

G. The SPD shall be compliant with the restrictions of the Hazardous Substances (RoHS) Directive 2002/95/EC.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Refer to Division 26, Section "General Electrical Requirements".

B. Service Conditions: Rate SPD devices for continuous operation under the following conditions unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
3. Humidity: 0 to 85 percent, noncondensing.
4. Altitude: Less than 20,000 feet (6090 m) above sea level.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

PART 2 - PRODUCTS

2.1 SPD'S FOR LIGHTNING PROTECTION

A. Lightning Protection Systems specified or otherwise required to be "Master Labeled" per UL 96A will require either a TYPE 1 (20kA rated I_n) SPD or a TYPE 2 (20kA rated I_n) SPD.

PANELBOARD SUPPRESSORS internally mounted in panelboards

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

1. Current Technology; a subsidiary of Danahar Corporation.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Liebert Corporation.
5. Siemens Energy & Automation, Inc.
6. Square D; a brand of Schneider Electric.

C. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, Current edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:

a. LED indicator lights for power and protection status.

2. Peak Single-Impulse Surge Current Rating:
a. 80 kA per mode/160 kA per phase

3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.

a. Line to Neutral: 70,000A
b. Line to Ground: 70,000A
c. Neutral to Ground: 50,000A

4. Protection modes and UL 1449 SVR for grounded wye circuits with three-phase, four-wire circuits shall be as follows:

	480Y/277 V	208Y/120 V	600Y/347 V
Line to Neutral	800	400	1200

Line to Ground	800	400	1200
Neutral to Ground	800	400	1200

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install SPD devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

1. Provide multiple, 30-A circuit breaker as a dedicated disconnecting means for SPD unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
3. Complete startup checks according to manufacturer's written instructions.

C. SPD device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Do not energize or connect any equipment to their sources until SPD devices are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the SPD installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to maintain SPD devices.

END OF SECTION

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Included in the work of this section are labor, material, and appurtenances required to complete the work of this Section as specified herein, including, but not limited to:

1. Interior light fixtures, lamps, LEDs, reflectors, lenses or faceplates, ballasts, transformers, drivers and power supplies (includes exterior light fixtures normally installed on exterior surfaces of buildings).
2. Exit signs.
3. Light fixture supports.
4. Emergency Lighting Mini-Inverter.
5. Coordination.
6. Quality assurances.
7. Specific requirements.

1.2 SUBMITTALS

A. General:

1. Only those light fixtures and manufacturers per each fixture type designated and listed in the Light Fixture Schedule or on the Drawings, and approved in accordance with paragraph 1.4-SUBSTITUTIONS of this Section, or both, will be accepted. Where the Light Fixture Schedule indicates an allowance to be made for a specific light fixture, the price is a contractor price and monies shall be allotted for freight, installation, and lamping (if designated). Alternate manufacturers presented at bid shall be disqualified.
2. Submit all light fixtures, specified for use on this Project, in a single submittal package of portfolios, so that all light fixtures can be reviewed at one time.
3. Prepare portfolios from manufacturer's standard specification sheets, and include the fixture tag indicated on the Light Fixture Schedule to identify each light fixture. Do not combine more than one light fixture type on a single sheet.
4. Fixture or other materials shall not be shipped, stored, or installed into the work without approval of shop drawings.
5. Modifications to fixtures shall be in accordance with Architect's comments.

B. Product Data: For each type of light fixture, collated and bound in sets, and arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Summary page with the following for each light fixture type

    a. The number, type and wattage of the light fixture lamps or LEDs (including, but not limited to, assemblies, arrays, bars or modules).
    b. Light fixture ballast, driver or auxiliary device manufacturer, number and type.

2. Fixture cut sheets with name of manufacturer and options to be provided marked, including, but not limited to, voltage, lensing, and finish/color.

a. Descriptive information providing physical characteristics of light fixture, including, but not limited to, materials, dimensions, fixture efficacy and/or efficiency, and verification of indicated parameters.
b. For LED fixtures, include also L70 lifetime and wattage of luminaire including driver/power supply losses.

1) Include MacAdam ellipse step information for:

a) All interior light fixtures
b) Exterior luminaires installed on exterior building surfaces specified with 80 CRI or greater.

3. Light fixture mounting details, including non-standard outlet boxes.
4. Construction of light fixture housing and door (if applicable).
5. Ballast cut sheet with options marked, providing physical description of ballast including, but not limited to, voltage, lamp, ballast factor, power factor, amperage and wattage.
6. Power supply, transformer, and/or driver cut sheet with options marked, providing physical description of auxiliary device including, but not limited to, voltage, power factor, amperage, wattage, and maximum remote distance charts between device and light fixture.
7. Light fixture finish and color (if applicable).
8. Lamp cut sheet with options marked, providing physical description of lamps, including, but not limited to, voltage, wattage, efficacy, CCT, CRI, lumens, and life expectancy.
   a. For LED lamps, include also number of MacAdam ellipse steps and L70 lifetime.

C. Shop Drawings: Show details of non-standard or custom light fixtures. Indicate dimensions, finish color, including, but not limited to, custom color, weights, methods of field assembly, components, features, accessories, and modifications. Scaled documents shall be provided for custom fixtures.

D. Submittal Schedule

1. Within 30 days of Division 26 contractor award, shop drawings covering all light fixtures within this section shall be forwarded to architect to begin approval process. Any shop drawings submitted after the required time frame will require the contractor to submit only the 1st named manufacturer and associated specification data listed on the fixture schedule as the only approved manufacturer. No substitutions will be allowed after the specified time frame.
2. Within 15 days of "approved" and "approved as noted" shop drawings, contractor shall forward to Architect a guaranteed ship date for each specified fixture.
3. Within 15 days after contractor's receipt of "reject and resubmit" or "not approved" shop drawings, contractor shall provide Architect with resubmitted shop drawings for only those fixtures deemed unacceptable.
4. Contractor is responsible to call to the attention of the Architect any submittals that have not been returned to him in a timely manner that may affect delivery of fixtures or as otherwise affecting Section 1.4.D of this specification.

E. Control Wiring

F. Coordination Drawings: Refer to architectural reflected ceiling plans or details for exact location of light fixtures; engineering documents shall not be referenced for exact fixture positions. Contractor shall check and verify dimensions and details on drawings before proceeding with the work. If any question arises about the true meaning of drawings, refer the matter to the Architect, whose decision is final. In no case proceed with work with any uncertainty. Architectural documents shall show and coordinate with assistance from installers of items involved:

1. Light fixtures.
2. Suspended ceiling components.
3. Structural members to which suspension systems for light fixtures will be attached.
4. Other items in finished ceiling including the following:
5. Air outlets and inlets.
6. Speakers.
7. Sprinklers.
8. Smoke and fire detectors.
9. Occupancy sensors.
10. Access panels.

G. Samples for Verification: For products designated for sample submission in Light Fixture Schedule, or at the request of Owner or Architect. Each sample shall include lamps, LEDs, ballasts and/or drivers. Sample shall be exact light fixture intended to be supplied for the project and equipped with 120-277V universal voltage and 120V cord and plug. Provide with pendant or wall support system if appropriate.

H. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

I. Qualification Data: For agencies providing photometric data for light fixtures.

J. Field quality-control test reports.

K. Operation and Maintenance Data: For lighting equipment and fixtures to include in operation and maintenance manuals.

L. Warranties: Special warranties specified in this Section.

1.3 SUBSTITUTIONS

A. Refer to Division 26 Section "General Electrical Requirements".

B. Prior to the Bid Date, substitutions will not be considered unless the Architect/Engineer have received written request for approval at least ten calendar days prior to the date for receipt of Bids. Include in each such request the Light Fixture Schedule designation, name of the material or equipment for which it is to be substituted and complete Product Data for the proposed substitute, as defined in SUBMITTALS above, and all other information necessary for an evaluation. Provide interior point-by-point photometric calculations, under both normal and emergency lighting conditions, as applicable, if required by the Engineer. Submit a $100.00 review fee to the Engineer with each such point-by-point calculation for use of electronic base files. The fee will be returned if the substitution is added to the specification.

C. During the Bid

1. Any proprietary, sole-sourced light fixture listed in the fixture schedule shall be unit priced only. Unit prices shall be clearly identified on the bid form.
2. Representative agents shall be allowed to offer mini-lot pricing (MLP). MLP shall be defined as:

    a. Agents can group only specified fixtures they represent, and
    b. Only represent in the region where the specification originated, and
    c. Exclude all fixtures outside their represented lines from the MLP, and
    d. Sole-sourced (proprietary) light fixtures shall not be included in the MLP.

3. Packaging of light fixtures will not be considered nor approved. Packaging is defined as: distributor(s) providing a single price for a light fixture package made up of specified and non-specified light fixtures. Any submittal package containing non-specified light fixtures or inclusion of lighting control systems will be immediately rejected in its entirety.

D. After the Bid Date, proposals to substitute light fixtures for those shown on the Drawings or specified herein, will only be considered as a deduct. Submit proposed substitutions separately, in Submittal form, with a list of proposed substitutions together with a deduct price for each substitution. Proposed substitutions will then be reviewed by the Architect/Engineer.

E. During the construction period, no substitutions shall be considered if product delay is due to contractor's failure to order products in a timely manner after presentation of fixture schedules and specifications. Additional costs associated with air freight or special factory runs to meet schedule due to contractor's error shall be at the expense of contractor.

F. The Architect/Engineer has the final authority as to whether the light fixture is an acceptable replacement to the specified item. The proposed substitution may also be rejected for aesthetic reasons if felt necessary or desirable. In the event the proposed substitutions herein described are rejected, provide the specified item(s).

1.4 DEFINITIONS

A. BF: Ballast factor.

B. CCT: Correlated color temperature

C. CFL: Compact Fluorescent

D. CRI: Color-rendering index.

E. CU: Coefficient of utilization.

F. EISA: Energy Independence and Security Act of 2007.

G. HID: High-intensity discharge.

H. L70: minimum 70% maintained initial-rated lumens at average rated life for LEDs

I. LED: Light Emitting Diode

J. LED Lamp: Replaceable LED light source with an integral driver within envelope of lamp. Lamp/Base types may include MR16/bi-pin, PAR/medium base, etc.

K. LED Module: Light source that contains LEDs, and may include additional components such as lenses, reflectors, or refractors, however do not include drivers.

L. LER: Light fixture (Luminaire) efficiency rating.

M. Light Fixture: Complete light fixture, including ballast housing if provided.

N. RCR: Room cavity ratio.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
2. Marked for intended use.

B. Comply with NFPA 70.

C. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

D. Regulatory Agencies: Provide fixtures conforming to nationally- or internationally-recognized accredited testing agencies, such as U.S., ETL, ARL, or others in acceptance with local code enforcement policy.

E. Electrical Components and Devices: Provide only fixtures that comply with National Electric Code (NEC), and in particular to Section 410. All ceiling recessed fixtures, whether indicated in a catalog number or not, shall be equipped with an integral thermal protection device.

1.6 COORDINATION

A. Unless otherwise noted, perform all electrical Work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other Divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.

B. Coordinate layout and installation of light fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including, but not limited to, HVAC equipment, fire-suppression system, and partition assemblies. Contractor shall arrange his installation in proper relation to other work so that there shall be no interference, damage or delay to other trades' work

C. Give ample notice of any special openings or rough-in work required for placing electrical/lighting work so as to avoid cutting or removal of completed work.

D. Where work of this Section is to be flush or concealed, install it so it does not project beyond finished lines of walls, ceilings or floor surface.

E. Verify all ceiling systems and coordinate light fixture type and accessories prior to ordering light fixtures. Coordinate and cooperate with ceiling installer in regards to the location and installation of light fixtures.

1.7 WARRANTY

A. General Guarantee: For a period of one year after Owner's initial acceptance and establishment of the beginning date of the guarantee period, and at no cost to the Owner, Contractor shall promptly furnish and install replacements for any fixtures or components deemed by the Owner as defective in workmanship under normal operating conditions, excluding lamp replacement as noted in Section 1.10.A.1. Contractor shall repair installed equipment on the job site to Owner's satisfaction. For any time during said guarantee period that fixtures are not fully functional due

to defects in material or workmanship, Contractor shall provide or pay for suitable temporary light fixtures, and shall remove said temporary fixtures upon installation of replacement elements. Contractor shall furthermore guarantee replacement fixtures for a period of one year following replacement.

B. Contractor shall not be held responsible for damage of fixtures or equipment components occurring after the beginning of the guarantee period due to acts of vandalism, acts of war, or acts of God.

C. LED Warranties: Shall be free from defects in materials and workmanship for the period indicated from date of factory shipment.

1. LED Luminaires, including LED modules, arrays and drivers: Five years.
2. LED Lamps: Three years.

PART 2 - PRODUCTS AND MATERIALS

2.1 MANUFACTURERS

A. In Light Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Basis-of-Design Product: The design for each light fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified that meets or exceeds performance characteristics of the named product.

2.2 LIGHT FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Provide light fixtures as shown on the drawings and/or specified. This shall include all lamps, material and labor to securely hang light fixtures, clean them and make them completely ready for use. Provide all hangers, supports, and miscellaneous hardware required to install light fixtures. Provide additional tie wires connected to structure to conform to applicable seismic requirements where required.

B. Light fixture models scheduled on the Drawings are to show the manufacturer, grade and style of light fixtures required. Regardless of the manufacturer's catalog number suffixes indicated, provide all options and features as described in the Light Fixture Schedule.

C. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures. Manufacturer of recessed fixtures shall provide mounting brackets suitable for connection to ceiling system structure. Modifications to standard mounting brackets shall be coordinated with contractor and delivered with fixture so that no delays to product delivery shall be allowed.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

F. 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.

G. 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.
4. Laminated Silver Metallized Film: 90 percent.

H. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

   a. Lens Thickness: At least 0.125 inch > minimum unless different thickness is indicated.
   b. UV stabilized.

2. Glass: Annealed crystal glass, unless otherwise indicated.

I. Where located within structural concrete, light fixture housing and any other luminaire components in direct contact with concrete shall be effectively coated and/or covered to prevent chemical reactions with the concrete in accordance with the American Concrete Institute Code.

J. Fixture Finishes:

1. Apply fixture finishes after fabrication in a manner that assures a durable wear-resistant surfacing. Give exposed metal surfaces (brass, bronze, aluminum and others) and finished castings, except chromium-plated or stainless steel parts, an even coat of high-grade meth/acrylate lacquer or transparent epoxy.

K. Reflectors:

1. Provide aluminum reflectors or reflecting cones for downlight style fixtures comprised of #12 aluminum reflector sheet, 0.57 inch (15 gauge) or heavier and free of tool-making indentations, including spinning lines caused by assembly techniques. All reflectors shall be of first-quality, anodized finish :Alzak" with specular or semi-specular finish and color as selected. Provide specular reflectors with no apparent brightness above 45 degrees from Nadir and semi-specular, diffuse reflectors with no apparent brightness above 75 degrees from Nadir.

L. Mounting hardware and trims:

1. Coordinate as need to suit ceiling conditions.
2. Light fixtures near or in contact with insulation shall comply with code.
3. Maintain a 3" minimum working clearance between non-IC rated light future housings and insulation on all adjacent ductwork, piping, walls and ceilings.

M. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps, LEDs, ballasts and/or drivers. 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, LEDs, ballast and/or driver characteristics:

a. "USE ONLY" and include specific lamp or LED type.
b. LED type, wattage, beam angle (if applicable) for LED luminaires. Indicate maximum allowed wattage.
c. CCT and CRI for all luminaires.

N. Emergency lights and exit signs with integral battery back-up shall be connected to a separate unswitched conductor bypassing all other controls and contactors. Exit signs shall not be switched. Allow battery to charge for a minimum of 48 hours before light level testing. In order to prevent battery damage, do not turn off power for extended periods of time after the emergency light has been powered.

2.3 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, nickel-cadmium type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. 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 flashing red LED.

2.4 DRIVERS FOR LED LUMINAIRES

A. Description: Designed for type and quantity of LED diodes of light fixture. Drivers shall tolerate sustained open circuit and short circuit output conditions without damage. Driver shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Sound Rating: A.
2. Total Harmonic Distortion Rating: Less than 20 percent. Shall comply with ANSI C82.77.
3. Transient Voltage Protection: IEEE C62.41, Category A or better.
4. Power Factor: 0.90 or higher at full load.
5. Interference: Comply with 47 CFR, Chapter 1, Part 15, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
6. Driver shall operate with maximum sustained variations of +/-10% input voltage and frequency with no damage to driver.
7. Driver output shall be regulated to maximum +/- 5% published load range or requirements of downstream LED fixture.
8. LED Current Crest Factor: 1.5 or less.

9. LED drivers shall not over-drive LEDs at a current or voltage above LED rated values in order to increase LED lumen output.
10. Meets EN610000 for input harmonics.
11. ROHS Compliant.

B. Dimming Drivers:

1. Dimming Range: Visually flicker-free, strobe-free, continuous dimming of source as follows, unless specifically noted otherwise in the Light Fixture Schedule whichever is more stringent:

   a. Luminaires: 100 to 10 percent of rated lumens.
   b. Lamps: 100 to 20 percent of rated lumens.

2. 0-10V dimming drivers: Compliant with IEC 60929 standard for 4-wire dimming.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and LED indicated.
4. Control: Coordinate to ensure that the dimming driver, power supply, controller, dimming module, and/or wallbox dimmer and connecting wiring are compatible.

2.5 EMERGENCY LIGHTING MINI-INVERTER

A. Manufacturer

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

   a. Bodine (by Signify),
   b. Carpenter Emergency Lighting,
   c. Chloride (by Signify),
   d. Controlled Power Company,
   e. Cooper Lighting,
   f. DSPM, Inc,
   g. Dual Lite,
   h. Emergi-Lite,
   i. Iota Engineering (Acuity Brands),
   j. Inverter Systems, Inc (ISI),
   k. Myers Emergency Power Systems,

B. Description – Self-contained uninterruptible or fast-transfer inverter designed for normal and emergency operation of connected lighting loads. Unit shall be capable of operating HID, incandescent, fluorescent, induction and LED fixtures with no break or interruption of illumination. UL 924 listed and meets NFPA 101, NFPA 70 and local codes.

1. Battery: Sealed, maintenance-free lead-calcium or lead-acid type. 68 deg F to 86 deg F optimum operating temperature.
2. Charger and Electronics: Fully automatic, thermal compensating variable rate battery charger. AC lockout feature, low battery voltage disconnect; DC overload, short circuit and brownout protection. 32 deg F to 104 deg F electronics operating temperature.
3. Operation: Inverter shall allow connected emergency lighting fixtures to be normally on. Upon loss of normal utility power, the emergency lighting fixtures will be delivered emergency power for their full lumen output rating with no break (<2 ms) in illumination for a minimum of 90 minutes.

4. 120V, single phase input and output voltages. Input voltage shall match output voltage, and +/- 3% voltage regulation, 60 Hz.
5. Maximum remote mounting distance of 1000'-0".
6. Housing: Designed for surface mounting installation to floor or wall. 16 gauge steel housing with scratch-resistant powder coat paint finish..
7. Testing: Integral testing means by either manual test switch or self-testing, self-diagnostic with manual testing capabilities.
8. Onboard LED indicating lights for inverter status indication.
9. Manufacturer's warranty or minimum 2 year warranty on electronics and battery and seven-year prorata warranty on battery, whichever is greater.
10. Overload and short circuit protection on input and output of inverter. Circuit breakers or fusing on output side.

C. Where wattage of inverter is different from Basis-of-Design manufacturer's selected wattage, provide quantity of inverters as required to meet design intent. If additional inverters are required, confirm additional equipment will fit within available space constraints.

D. Where physical size of inverter is different from Basis-of-Design manufacturer, confirm equipment will fit within available space constraints.

2.6 LED LAMPS AND LUMINAIRES

A. Comply with ANSI C78.377 for white light LED color range. Unless noted otherwise in the Light Fixture Schedule, LED color quality characteristics shall be 80 CRI minimum and CCT as indicated in Light Fixture Schedule.

B. LED binning specification tolerance to be within 3 MacAdam ellipses of rated values or as indicated in the Light Fixture Schedule, whichever is more stringent. All LEDs used for same fixture type throughout the project to originate from same production bin.

C. Unless indicated otherwise in the Light Fixture Schedule, minimum 70% maintained initial-rated lumens at average rated life of as follows:

1. LED lamps: 20,000 hours
2. LED luminaires: 50,0000 hours

D. ROHS compliant

E. Manufacturer of LED chips will be evaluated based on the manufacturer's product literature and data. At a minimum, LED fixtures or lamps will incorporate Bridgelux, Cree, Nichia, Osram or Xicato LEDs; additional manufacturers may be considered however the Architect or Engineer has the authority to reject other manufacturers for technical or aesthetic reasons if felt necessary or desireable.

2.7 AUXILIARY DEVICES FOR LOW VOLTAGE AND LED FIXTURES

A. Provide remote power supplies, drivers and/or transformers for light fixtures as required for a complete and operational system. Where equipment is not indicated as plenum rated, provide an additional enclosure for the device(s) suitable for the installed environment.

2.8 LIGHT FIXTURE SUPPORT COMPONENTS

A. Comply with Sections "260548 Seismic Controls for Electrical" and "260529 - Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.9 TRANSFORMERS FOR LOW VOLTAGE FIXTURES

A. Provide transformers to low voltage lamps which are suitable for the electrical characteristics of the supply circuits to which they are to be connected. For remote electronic or magnetic transformers, contractor shall remote transformers so as to reduce voltage drop. For 25 amp low-voltage linear systems, contractor shall not daisy-chain 25A loaded runs together. Contractor shall provide home-run from end of run to remote transformer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify conditions of equipment and installation prior to beginning work.

B. Verify that equipment is ready for connecting, wiring, and energizing.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Light Fixtures: All work shall be executed to present a neat appearance. Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

C. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

D. Support for Light Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from light fixture corners.

2. Support Clips: Fasten to light fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on light fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

E. Suspended Light Fixture Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end. Provide suitable connectors or collars to connect adjoining units to appear as a continuous unit.
4. Decorative pendant mounted light fixtures

    a. Provide cord and/or stem lengths to match elevations above finished floor as indicated on architectural elevations. If architectural elevations do not indicate suspension heights, coordinate with Architect to determine final suspension heights. Regardless, contractor shall not field cut pendants or order rigid stems without elevation approval from Architect. Pendant suspensions on electrical documents are for reference only.

        1) Cord-mounted: Manufacturers shall supply luminaires with flexible, field cutting cords. Contractor shall field cut cords as required.
        2) Field-cuttable, rigid-stem mounted: Manufacturers shall supply luminaires with field cutting rigid stems. Contractor shall field cut stems as required.
        3) Factory-cut rigid stem mounted: Contractor shall provide rigid stem dimensions to the manufacturer as required.

    b. Junction boxes used to feed light fixtures shall be covered by manufacturer supplied canopy plates.

F. Installation within non-standard ceilings, including, but not limited to, wood and metal ceilings.

1. For recessed downlight light fixtures, specification is based on standard throats to accommodate ceiling thicknesses of ¾" or less. If non-standard ceiling (such as wood, thickened gypboard ceilings and metal plank type) require throats greater than ¾", modifications to manufacturer's standard ¾" throat shall be determined by Architect and Contractor prior to shop drawing submission.
2. For light fixtures recessed into metal ceilings, rigidly support light fixture to ensure that trim fits flush with ceiling plane.

G. Manufacturer shall supply contractor with a complete list of component elements to comply with design intent for either 20-amp (flexible low voltage track systems or line voltage track) or 50-amp bus bar track systems. Contractor shall install track systems based on design requirements outlined herein or Light Fixture Schedule.

H. Connect wiring according to Section "260519 - Low-Voltage Electrical Power Conductors and Cables."

I. Through wiring of recessed light fixtures, in suspended ceilings, is not permitted. Connect each light fixture by a whip to a junction box. The whip shall be of sufficient length to allow the light fixture to be relocated within a 6-foot radius.

J. Wall Mounted Light fixtures

1. Unless otherwise noted, conceal all raceways and back boxes for wall mounted light fixtures. Coordinate all wall-mounted light fixtures with interior elevations. Where specific elevations or dimensions are not indicated, verify the correct location with Architect prior to installation. Contractor shall supply structure to support weight of fixture.

K. Contractor shall construct light coves according to architectural details. Contractor shall ensure, unless otherwise directed, that top of fixture lamp is flush with top of cove lip. Contractor shall provide blocking as needed under fixture to ensure stated requirement.

L. Auxiliary Devices for low voltage and LED Fixtures

1. Install device within maximum remote distances and with wiring sized per manufacturer's recommendations.
2. In public areas or other areas where remote device visibility is undesireable, install device where concealed from view, well ventilated and accessible. Provide access panels as required.
3. Provide label on device indicating fixture type and location/room served along with panelboard circuit number.
4. Properly support remote lighting devices, including transformers, power supplies, and drivers, per Code and manufacturer's recommendations.

3.3 DIMMING

A. For dimmable light fixtures, provide both control and power wiring between light fixture and control device and between light fixtures. Quantity of low voltage and line voltage wiring and wire type shall be per manufacturer's recommendations. At a minimum, provide the following based on control type at either 120V or 277V, unless recommended otherwise by the manufacturer:

1. 0-10V – two low voltage conductors and two line voltage conductors plus ground

B. Coordinate light fixture and control device dimming types for compatibility.

3.4 COORDINATION

A. Light fixtures shown on the Electrical Drawings represent general arrangements only. Refer to Architectural Drawings for exact locations.

B. Coordinate the installation and location of light fixtures with other work and all other trades before installation to avoid conflicts. Coordinate light fixture locations in mechanical rooms with final installed piping and ductwork layouts.

C. Verify all ceiling systems and coordinate light fixture type and accessories prior to ordering light fixtures. Coordinate and cooperate with ceiling installer in regards to the location and installation of light fixtures.

D. Coordinate final light fuxture locations in walk-in coolers and freezers with refrigeration coils and other trades.

E. Wall-Mounted Light fixtures

1. Coordinate all wall-mounted light fixtures with the architectural features of the building. Where specific elevations or dimensions are not indicated, verify the correct location with the Architect prior to beginning any work.

3.5 ADJUSTING

A. Contractor shall adjust all light fixture sockets to match the lamp specified and aim all adjustable light fixtures as directed by the Architect.

B. Where required, focusing shall be done during hours of darkness. Upon notification by contractor that all fixtures are correct as per shop drawings and functioning, that specified lamps have been verified, lighting designer or Architect shall coordinate with contractor as to a mutually agreed upon time to complete focusing. Failure of contractor to notify Architect during substantial completion will result in failure to comply with specifications.

3.6 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Clean light fixtures of dirt and debris upon completion of the installation. Protect installed light fixtures from damage during the remainder of the construction period.

C. Upon completion of the installation of light fixtures, and after building circuits have been energized, energize lighting branch circuits to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

D. At the time of final acceptance of this project by the Owner, ensure that all lamps are in working order and all light fixtures are fully lamped.

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.

END OF SECTION