Project Manual

HCA MIDWEST HEALTH

LEE'S SUMMIT MEDICAL CENTER

Lee's Summit Medical Center ICU Expansion

2100 SE Blue Parkway
Lee's Summit, Missouri

Volume 2 of 2

(Divisions 15 thru 32)

January 14, 2022

ACIB Project #3-21112

ACI BOLAND ARCHITECTS

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SECTION 21 00 10
GENERAL FIRE SUPPRESSION REQUIRMENTS

PART 1 - GENERAL REQUIREMENTS

1.01 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 21 of the Specifications and Drawings numbered with prefixes FX generally describe these systems, but the scope of the Fire Suppression work includes all such work indicated in the Contract Documents: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Fire Suppression, Mechanical, Plumbing, Fire Alarm 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 location and arrangement of the equipment, piping, etc. without showing all the exact details as to elevations, offsets, pipe routing, 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.

D. 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 21 Section 210500 "Common Work Results for Fire Suppression," for materials and methods for wall and floor penetrations.
3. Division 21 Section 210515 "Basic Fire Suppression Piping Material and Methods," for general piping and fitting materials and methods.
4. Division 21 Section 210548 “Seismic Controls for Fire Protection” for seismic bracing requirements.
5. Division 21 Section 211313 "Water-based Fire Suppression Systems" for fire suppression sprinkler systems inside the building.

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

E. 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.

F. Threaded joints shall conform to ASME B1.20.1, Pipe Threads, General Purpose and the Pipe Fitters Handbook.

G. Regulatory Requirements: Comply with all standards listed in Section 1.2 and all applicable local requirements.

H. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of this Section, Division 26 and Division 28.

I. 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.

1.03 CODES, REFERENCES AND STANDARDS

A. Execute Work in accordance with the National Fire Protection Association Standards 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 submission 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.

1. NFPA (National Fire Protection Association) 13, “Installation of Sprinkler Systems”, 2010 Edition.
2. NFPA 25, “Inspection, Testing and Maintenance of Water-Based Fire Protection Systems”, 2011 Edition.
3. Underwriters Laboratories, “Fire Protection Equipment Directory”, Latest Edition.
4. HCA Healthcare Design and Engineering Guidelines for Hospitals, 2021 Edition

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

F. All Fire Suppression 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 Fire Suppression work shall be provided by the Contractor.

1.04 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.

C. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

D. Other definitions for fire protection systems are listed in NFPA Standards 13 and 24.

E. Working Plans, also referred to as Fire Protection Drawings as used in this Section means those documents (including drawings and calculations) prepared pursuant to the requirements contained in NFPA 13 for obtaining approval of the Authority Having Jurisdiction.

F. 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. Sub-base: as used in this Section refers to the compacted soil layer used in pavement systems between the subgrade and the pavement base course material.
3. Subgrade: 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 subgrade elevations or dimensions without specific direction from the Architect.

1.05 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 in the manner anticipated in the design.

C. 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 Fire Suppression 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.

D. 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/Engineer. 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.

E. The contractor shall coordinate work in this section with all related trades. Work and/or equipment provided in other sections and related to the fire protection system shall include, but not be limited to:

1. Sprinkler monitoring equipment (water flow switches, valve tampers, etc) shall be provided by the fire sprinkler installer, but wired and connected by Division 28.

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

1.06 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.

1.07 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.

1.08 SUBMITTALS

A. Refer to Division 01 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. 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 Fire Suppression 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 shop drawings prepared in accordance with referenced standards identified as "Working Plans", including hydraulic calculations where applicable. Shop drawings shall be signed and sealed by a Professional Engineer registered in the state in which the project is located where required by local authorities having jurisdiction, or NICET Level III or IV certified technician. Submit copies of the certification for the designer with submittal. Shop drawings consisting of the following shall be furnished at a minimum. Refer to NFPA 13 for additional requirements.

1. Scaled site plan indicating underground piping with sizes and hydrants utilized for flow test in relation to the building.
2. Layout drawings of complete fire sprinkler system indicating relationship to all other trades. This shall include all equipment, piping and a reflected ceiling plan indicating sprinkler locations.
3. Complete details and sections as required to clearly define and clarify the design indicated.
4. Shop drawings shall be to a standard scale and not less than 3/32" = 1'-0".
5. Shop drawings shall be produced using computer-aided design. Hand drawn documents will not be reviewed or approved.
6. Hydraulic calculations shall be based on a water flow test conducted at the site within twelve (12) months of the submittal of plans for approval. The contractor shall be responsible for obtaining the flow test if existing data is not available. Flow test information shall be documented on shop drawings with an accompanying site plan to scale. Contractor shall verify with AHJ any minimum safety factor requirements. Demand shall not be less than 10 percent below the supply at the demand point.
    a. Hydrant testing shall be in accordance with NFPA 13 and 291 requirements.

M. Contractor shall prepare installation drawings (working shop drawings) based upon this design. Requests for deviations from the approved design shall be submitted in writing to the Engineer of Record for approval. Shop drawings showing deviations from the design without prior approval will not be approved.

N. Provide welders' qualification certificates.

O. Provide Test Reports and Certificates including:
1. "Contractor's Material & Test Certificate for Aboveground Piping"

P. Contractor to submit engineer approved sprinkler shop drawings to HCA's insuring agency, AIG, for review. Email plans to planreview.americas@aig.com and copy james.dipaoli@aig.com. Anthony's alternate contact information is:

Jamie DiPaoli, PE

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1.09 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF 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. Contact the Architect for Architect's written authorization. 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. In addition to payment, Architect's written authorization and Engineer's release agreement form must be received before electronic drawing files will be sent.

1.10 SUBSTITUTIONS

A. Refer to Division 1 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.

1.11 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 for the project, furnish to the Architect, for Engineer’s review,and for 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. Include the following sections with the appropriate information for each section:
1. Typewritten Index.
2. Qualifications. Provide designer and installer qualification.
3. Bill of Materials. Provide complete nomenclature, model number and vendor information for all parts.
4. Operating Instructions. Complete instructions detailing operation and maintenance of all equipment installed.

5. Product Data: Provide product cut-sheets for all equipment utilized and installed.
6. Guarantee. Copy of all guarantees and warranties issued.
7. Testing/Certification: Provide all completed testing and certification forms as required per NFPA 13 and 25.
8. Contact list with minimum three service representative phone numbers.

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.

1.12 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections in Division 21 specifications.

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 Architect/Engineer.

D. The fire shop drawings and all information contained therein shall be utilized as the basis for the Record Drawings.

1.14 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 a format as agreed to with the Owner. Provide three copies of each session to the Owner and obtain written receipt from the Owner.

1.15 PAINTING

A. Exposed ferrous surfaces, including pipe, pipe hangers, equipment stands and supports shall be painted by the Fire Suppression 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.

1.16 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.

1.17 GUARANTEES AND WARRANTIES

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

B. Furnish service and maintenance of fire protection system for one year from date of substantial completion.

C. 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.

D. The following additional items shall be guaranteed:

1. Piping shall be free from obstructions, holes or breaks of any nature.
2. Proper sloping of pipe to drain in each piping system per NFPA 13.

E. The above guarantees shall include labor (including travel expenses), troubleshooting and material; and repairs or replacements shall be made without additional cost to the Owner.

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

G. 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 and stating the commencement date and term.

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 Fire Suppression Contractor shall perform the demolition which involves Fire Suppression and Fire Suppression systems, equipment, piping, equipment supports or foundations and materials.
4. Fire Suppression Contractor shall remove articles which are not required for the new work. Unless otherwise indicated, each item removed by the Fire Suppression Contractor during this demolition shall be removed by the Fire Suppression Contractor from the premises and disposed of in accordance with applicable federal, state and local regulations.
5. Fire Suppression Contractor shall relocate and reconnect Fire Suppression equipment that must be relocated in order to accomplish the remodeling shown in the Drawings or indicated in the Specifications. Where Fire Suppression equipment or materials are removed, the Fire Suppression 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 Fire Suppression 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.
3. Use of explosives is not permitted.

C. 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

2.01 GENERAL

A. Electrical Contractors shall provide all motors, starters, disconnects, wire, conduit, etc. as specified in the Construction Documents. If, however, the Fire Suppression 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 Fire Suppression 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.

D. Refer to Division 28, "Fire Detection and Alarm" for specification of sprinkler monitoring equipment connections.

E. All fire protection equipment shall be UL listed for its intended use and in conformance with the applicable NFPA codes.

F. System Pressures: All system components shall be listed for the actual designed system pressures.
1. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall install, and test all new equipment identified in this contract and revise existing equipment as noted.

B. Installation shall be in accordance with NFPA requirements and the Contractor shall have employed or enlist the design services of at least one minimum NICET Level II certified technician.

C. Installer: Company specializing in the products indicated in this section with minimum three years documented experience. Shall be bondable and licensed contractor and employ full-time factory-trained and certified installers and technicians. Installers shall provide with the fire sprinkler submittal proof of factory training for each installer.

D. The Contractor shall provide all required equipment, sprinklers and piping for a complete and operational fire protection system. All components shall be installed in accordance with the guidelines of these specifications and documents as well as the NFPA codes and standards listed in these specifications.

E. 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.

3.02 PERMITS

A. Secure and pay for permits required in connection with the installation of the Fire Suppression 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.

3.03 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Section.

B. Report test results promptly and in writing.

3.04 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.

3.05 SELECTIVE DEMOLITION

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

B. Materials and equipment to be salvaged: Remove, demount, and disconnect existing Fire Suppression materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage.

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

D. Fire Suppression Materials and Equipment: Demolish, remove, demount, and disconnect the following items:

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

    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 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 21.

3.06 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 and Structural Engineer.

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.

3.07 CLEANING

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

B. Immediately prior to the final inspection, the Fire Suppression Contractor shall clean material and equipment installed under the Fire Suppression 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.

3.08 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.
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, they 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 21 00 10

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 21 05 00
COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with Fire Suppression installations as follows:
   1. Access panels and doors in walls, ceilings, and floors for access to Fire Suppression materials and equipment.
   2. Miscellaneous metals for support of Fire Suppression materials and equipment.
   3. Wood grounds, nailers, blocking, fasteners, and anchorage for support of Fire Suppression materials and equipment.
   4. Joint sealers for sealing around Fire Suppression materials and equipment.

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 21 Section 210010 “General Fire Suppression Requirements” for requirements for hydraulic calculations, obtaining electronic drawings files, shop drawings and record drawings.
   3. Division 21 Section 210515 "Basic Fire Suppression Piping Material and Methods," for general piping and fitting materials and methods.
   4. Division 21 Section 210548 “Seismic Controls for Fire Protection” for seismic bracing requirements.
   5. Division 21 Section 211313 "Water-based Fire Suppression Systems" for fire suppression sprinkler systems inside the building.

1.02 SUBMITTALS

A. General: Submit the following in accordance with Division 1 and Division 21 Section “General Fire Suppression Requirements”.
   1. Product data for the following products:
      a. Access panels and doors.
      b. Through and membrane-penetration firestopping systems.
   2. 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."

1.03 QUALITY ASSURANCE

A. 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.

PART 2 - PRODUCTS AND MATERIALS

2.01 ACCESS TO EQUIPMENT

A. Acceptable 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 Fire Suppression Piping and Equipment” 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.
9. Locking Devices: Where indicated on the drawings or where access panels are installed in locations accessible to the public, provide 5-pin or 5-disc type cylinder locks, individually keyed; provide 2 keys.

2.02 FIRE SUPPRESSION EQUIPMENT NAMEPLATE DATA

A. For each piece of power operated Fire Suppression 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.

2.03 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.

2.04 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.

1. Framing materials shall be fire resistant treated for use in Type I and II buildings.

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

1. Framing materials shall be fire resistant treated for use in Type I and II buildings.

2.05 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, 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. "OmniPlus," Sonneborn Building Products Div.

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.

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.

2.06 ACOUSTICAL SEALANTS

A. General: Penetrations by pipes through surfaces that are around and between noise critical spaces shall be sleeved, packed and sealed airtight with foam rod, non-hardening sealant and/or packing material as described herein.

B. Foam Rod: Foam backer rod shall be closed cell polyethylene suitable for use as a backing for non-hardening sealant.

C. Non-Hardening Sealant: Sealant for penetrations shall be non-hardening polysulphide type. Permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

D. Packing Material: Mineral fiber; non-combustible; resistant to water, mildew and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 15 pcf (40 kg/m3).

PART 3 - EXECUTION

3.01 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.

3.02 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

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

3.03 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 Fire Suppression 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.

3.04 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.

3.05 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.

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

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

J. All openings sleeved through underground exterior walls shall be sealed with mechanical sleeve seals as specified in Division 21 Section “Basic Fire Suppression Piping Materials and Methods

END OF SECTION 21 05 00

SECTION 21 05 15
BASIC FIRE SUPPRESSION PIPING MATERIALS AND METHODS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section specifies piping materials and installation methods common to more than one Section of Division 21 and includes piping, joining materials, piping specialties and basic piping installation instructions.

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

1. Division 21 Section 210010 “General Fire Suppression Requirements” for requirements for hydraulic calculations, obtaining electronic drawings files, shop drawings and record drawings.
2. Division 21 Section 210500 "Common Work Results for Fire Suppression," for materials and methods for wall and floor penetrations.
3. Division 21 Section 210548 “Seismic Controls for Fire Protection” for seismic bracing requirements.
4. Division 21 Section 210553 “Identification for Fire Suppression Piping and Equipment” for labeling and identification of installed fire suppression equipment.
5. Division 21 Section 211313 "Water-based Fire Suppression Systems" for fire-suppression sprinkler systems inside the building.

1.02 SUBMITTALS

A. Refer to Division 1 and Division 21 “General Fire Suppression Requirements” for administrative and procedural requirements for submittals.

B. Contractor to submit engineer approved sprinkler shop drawings to HCA’s insuring agency, AIG, for review. Email plans to planreview.americas@aig.com and copy james.dipaoli@aig.com. Anthony’s alternate contact information is:

Jamie DiPaoli, PE

99 High Street, 24h Floor, Boston MA 02110

Tel +1 617 457 5847 | Cell +1 862 245 3572

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

1. Piping and Fittings
2. Escutcheons
3. Dielectric Unions and Fittings
4. Sleeves and Mechanical Sleeve Seals
5. Wall Pipes

1.03 QUALITY ASSURANCE

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

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

C. Threaded joints shall conform to ASME B1.20.1, Pipe Threads, General Purpose and the Pipe Fitters Handbook.

D. UL Compliance: Fire protection system materials and components shall be Underwriter's Laboratories listed and labeled, and Factory Mutual approved for fire service.

E. Pipe, piping specialties and fittings shall be manufactured in plants located in the United States.

PART 2 - PRODUCTS AND MATERIALS

2.01 GENERAL REQUIREMENTS

A. All fire suppression system materials and components essential to successful system operation shall be listed for their intended purpose.

B. General: Refer to the individual piping system specification sections in Division 21 for specifications on piping and fittings relative to that particular system.

2.02 STEEL PIPE AND FITTINGS

A. All piping 2-inch and smaller:

1. With the use of threaded fittings: ASTM A135 or 795, Grade A, Schedule 40, seamless or ERW, black steel pipe. All 1-inch piping shall have threaded ends.

2.

B. All piping 2-1/2" and larger: ASTM A135 or 795, Grade A, Schedule 10, ERW, black steel pipe, roll grooved ends.

C. Acceptable alternatives to Schedule 40 and Schedule 10 pipe shall be manufactured to standards recognized by HCA Standards. Threaded pipe shall have a corrosion resistance rating (CRR) of 1.0 or greater. Crimp type couplings shall not be used. Victaulic's 'Press-fit' sprinkler piping or threadable thinwall pipe not permitted.

D. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

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

F. Steel Couplings: ASTM A 865, threaded

G. Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

H. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

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

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

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

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

M. Grooved-Joint, Steel-Pipe Appurtenances

1. Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
2. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
3. Grooved mechanical couplings including gaskets used on dry-pipe systems shall be listed for dry-pipe service.

2.03 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.

B. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

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

2.04 JOINING MATERIALS

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

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

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

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

E. Plastic, Pipe-Flange Gasket, and Bolts and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.05 LISTED FIRE-PROTECTION VALVES

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

B. Check Valves:
   1. Description: Swing-check type, rubber-face checks unless otherwise indicated, and ends matching piping.
   2. Standard: UL 312.
   3. Pressure Rating: 250 psig minimum.
   4. Type: Swing check.
   5. Body Material: Cast iron.
   6. End Connections: Flanged or grooved.

C. Bronze OS&Y Gate Valves:
   1. Description: Bronze body and bonnet and bronze stem.
   2. Standard: UL 262.
   3. Pressure Rating: 175 psig.
   4. Body Material: Bronze.
   5. End Connections: Threaded or grooved.

D. Iron OS&Y Gate Valves:
   1. Description: Iron body and bonnet and bronze seating material.
   2. Standard: UL 262.
   3. Pressure Rating: 250 psig minimum.
   4. Body Material: Cast or ductile iron.
   5. End Connections: Flanged or grooved.

E. Indicating-Type Butterfly Valves:
   1. Standard: UL 1091.
   2. Pressure Rating: 175 psig minimum.
   3. Valves NPS 2 and Smaller:
      a. Valve Type: Ball or butterfly.
      b. Body Material: Bronze.
      c. End Connections: Threaded or grooved.
   4. Valves NPS 2-1/2 and Larger:

a. Valve Type: Butterfly.
b. Body Material: Cast or ductile iron.
c. End Connections: Flanged or grooved.

5. Valve Operation: Integral, prewired supervisory switch and visual indicating device.

2.06 TRIM AND DRAIN VALVES

A. General Requirements:
1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing (FM insureds only).
2. Pressure Rating: 175 psig minimum.

B. Automatic (Ball Drip) Drain Valves:
1. Standard: UL 1726.
2. Pressure Rating: 175 psig minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4.
5. End Connections: Threaded.

2.07 AUTOMATIC AIR RELEASE VALVE

A. Standard: UL 2573
B. Pressure Rating: 175 psig minimum.

2.08 FIRE-DEPARTMENT CONNECTIONS

2.09 EXISTING TO REMAIN. PIPING SPECIALTIES

A. Escutcheons: 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.
1. One-Piece, Cast-Brass Type: With finish that matches existing and setscrew fastener.
2. One-Piece, Stamped-Steel Type: With finish that matches existing and spring-clip fasteners.
3. Split-Casting Brass Type: With finish that matches existing and with concealed hinge and setscrew.
4. Split-Plate, Stamped-Steel Type: With finish that matches existing, concealed hinge, and spring-clip fasteners.

B. Floor Plates: Inside diameter shall closely fit pipe outside diameter. Outside diameter shall completely cover the opening in floors, walls, or ceilings.
1. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
2. Split-Casting Floor Plates: Cast brass with concealed hinge.

C. Unions: Malleable-iron, Class 150 for low pressure service and class 250 for high pressure service; hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

D. Dielectric Unions and Fittings: Provide factory-fabricated dielectric unions and fittings with appropriate end connections for the pipe materials in which installed (screwed, soldered, or flanged), which effectively isolate dissimilar metals, prevent galvanic action, and stop corrosion.

E. Pressure Gauges
1. Standard: UL 393.
2. Dial Size: 3-1/2- to 4-1/2-inch diameter.
3. Pressure Gage Range: 0 to 300 psig.
4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

2.10 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.
3. 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.
4. 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.

B. Wall Pipes

1. Cast-iron sleeve with integral clamping flange with clamping ring, bolts, and nuts for membrane flashing.
    a. Underdeck Clamp: Clamping ring with setscrews.

C. Mechanical Sleeve Seals: Modular Plumbing 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.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
    a. Pressure Plates: Carbon steel or stainless steel.
    b. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, or Stainless steel of length required to secure pressure plates to sealing elements.

PART 3 - EXECUTION

3.01 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.

3.02 PIPING 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. Coordinate installation of horizontal piping with other components. Allow sufficient space above removable ceiling panels to allow for panel removal (minimum 6” clearance).

C. Install system such that all piping is rigidly secured and supported. All ductwork, lights, structural members and main runs of piping shall take precedence over sprinkler piping. Cutting of structural members for passage of sprinkler pipes or hangers shall not be permitted. All

horizontal piping in ceiling space shall be at an elevation above the top of light fixtures and air outlets to allow for access to light fixtures and air outlets without removing horizontal piping. Route all sprinkler piping and provide all offsets, bends, and elbows around all mechanical, electrical, and structural members as required.

D. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated otherwise. In areas with ceilings, piping shall be routed concealed, above ceiling. In areas without ceilings, piping shall extend as high as possible.

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

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

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 sprinkler piping to provide for system drainage in accordance with NFPA 13. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple and cap.

J. Coordinate pipe routing near electrical equipment in accordance with NFPA 70.

K. Verify final equipment locations for roughing in.

L. Deviations from approved "Working Plans" for sprinkler piping require written approval of the Authority Having Jurisdiction. Written approval shall be on file with the Engineer prior to deviating from the approved "Working Plans."

M. Install escutcheons for exposed piping penetrations of walls, ceilings, and floors.

3.03 JOINT CONSTRUCTION

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

B. Use approved fittings to make all changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

C. Install unions in pipes NPS 2 and smaller, adjacent to each valve. Unions are not required on flanged devices or in piping installations using grooved mechanical couplings.

D. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

E. Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

   a. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

G. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads and Pipe Fitter’s Handbook. 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.
   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 that are corroded, or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

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

I. Mechanical Grooved Joints: Roll grooves on pipe ends dimensionally compatible with the couplings. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

J. Joints for other piping materials are specified within the respective piping system sections.

3.04 ALARM DEVICE INSTALLATION

A. General: Comply with NFPA 24 for devices and methods of valve supervision.

B. Supervisory Switches: Supervise valves in open position unless noted otherwise.

1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.

2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.

C. Water-Flow Indicators: Install in fire suppression piping where indicated. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.

D. Connect alarm devices to building's fire-alarm system. Wiring and fire-alarm devices are specified in Division 28 Sections.

3.05 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 the end of each day or whenever work stops.

3.06 PENETRATIONS

A. Fire suppression 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. 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. 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.

D. 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 1/2-inch of sealant. Refer to Division 21 Section "Common Work Results for Fire Suppression" 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-inch annular clear space between inside of sleeve and outside of insulation.

E. 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 1/2-inch 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-inch annular clear space between inside of sleeve and outside of insulation.

F. Fire / Smoke Rated Floor and Wall Assemblies: Seal around penetrations of fire rated assemblies to maintain fire resistance rating of assemblies. Coordinate fire ratings and locations with the architectural drawings. Install sealants in compliance with the manufacturer's UL listing. Refer to Division 21 Section "Common Work Results for Fire Suppression" for firestopping and materials.

3.07 ACOUSTICAL PENETRATIONS

A. General: There shall be no direct contact of piping with shaft walls, floor slabs and/or partition. All openings around pipes in the structure surrounding the Fire Suppression equipment and surrounding noise-critical spaces shall be sealed, packed with caulking for the full depth of the penetration, as described herein. This includes all slab penetrations and penetrations of noise critical walls.

B. Fire Sprinkler Piping

1. Where a pipe passes through a wall, ceiling or floor slab of a noise critical space, a steel sleeve shall be cast or grouted into the structure. The internal diameter of the sleeve shall be 2 inches larger than the external diameter of the pipe passing through it. After all of the piping is installed in that area, the Contractor shall check the clearance and correct it, if necessary, to within 1/2 inch. Pack the void full depth with packing material sealed at both ends, 1 inch deep, with non-hardening sealant backed by foam rod.

3.08 PIPE FIELD QUALITY CONTROL

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

END OF SECTION 21 05 15

SECTION 21 05 48
SEISMIC CONTROLS FOR FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.01 RELATED DOCUMENTS

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

1.02 RELATED SECTIONS INCLUDE THE FOLLOWING:

A. Division 20 Section “Seismic Controls for MEP/F/T Systems” for general requirement and related documents that apply to this section.

1.03 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: International Code Council Evaluation Service.

1.04 SUMMARY

A. Seismic bracing, restraints, and controls for all fire protection systems specified herein shall be designed and installed as required by Division 20 Section “Seismic Controls for MEP/F/T Systems”.

1.05 SUBMITTALS

A. Provide submittals as required by Division 20 Section “Seismic Controls for MEP/F/T Systems” for all fire protection systems specified herein.

PART 2 - PRODUCTS AND MATERIALS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION 21 05 48

SECTION 21 13 13
WATER BASED FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. The extent of this fire sprinkler system shall be as specified herein. Contractor shall be responsible for preparation of design drawings, hydraulic calculations, fabrication and installation for complete fire sprinkler protection for the building.

B. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire protection valves.
3. Sprinkler pipe fittings.
4. Sprinklers.
5. Alarm devices.

C. Related Sections:

1. Division 21 Section 210010 “General Fire Suppression Requirements” for requirements for hydraulic calculations, obtaining electronic drawings files, shop drawings and record drawings.
2. Division 21 Section 210500 "Common Work Results for Fire Suppression," for materials and methods for wall and floor penetrations.
3. Division 21 Section 210515 "Basic Fire Suppression Piping Material and Methods," for general piping and fitting materials and methods.
4. Division 21 Section 210548 “Seismic Controls for Fire Protection” for seismic bracing requirements.

1.02 SYSTEM DESCRIPTION

A. Fire protection system in the location or portion of the building is a Wet Pipe System.

1. Wet Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to a water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts a fusible link or destroys a frangible device. Hose connections are included if indicated.

B. Provide system(s) as specified herein and as shown on drawings. The sprinkler system shall be supplied by the fire suppression system that is existing to remain as seen on site.

C. Provide dry pipe fire protection system for non-heated spaces and other areas of building subject to freezing including the loading docks and canopies, mansards, and balconies. Portions of systems subject to freezing or temperatures below 40° F shall be protected against freezing as required by NFPA 13. The Contractor shall be responsible for repairs and for all costs incurred from damage caused by freezing of the fire protection system.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design fire suppression system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Standard Pressure, Fire Suppression System Component: Listed for 175-psig minimum working pressure.

C. Performance Criteria

1. Protect entire area of work, unless noted otherwise, with a sprinkler system designed in accordance with NFPA 13 for Light Hazard requirements.

2. Protect mechanical and electrical areas/rooms with a sprinkler system designed in accordance with NFPA 13 for Ordinary Hazard Group 1 requirements.
3. Protect storage areas/rooms, unless noted otherwise, with a sprinkler system designed in accordance with NFPA 13 for Ordinary Hazard Group 2 requirement.
4. Design Criteria for Automatic-Sprinkler Piping Design:
    a. Light Hazard Occupancy:
        1) Minimum Design Density: 0.10 gpm over 1,500 sq.ft. area.
        2) Maximum protection area per sprinkler: 225 sq.ft.
        3) Minimum Combined Hose Stream Demand Requirement: 100 gpm for 30 minutes.
    b. Ordinary Hazard Group 1 Occupancy (Open areas):
        1) Minimum Design Density: 0.12 gpm over 3,000 sq.ft. area.
        2) Maximum area per sprinkler: 130 sq.ft..
        3) Minimum Combined Hose Stream Demand: 250 gpm for 60 to 90 minutes.
    c. Ordinary Hazard Group 1 Occupancy (Partitioned Areas):
        1) Minimum Design Density: 0.14 gpm over 2,000 sq.ft. area.
        2) Maximum area per sprinkler: 130 sq.ft..
        3) Minimum Combined Hose Stream Demand: 250 gpm for 60 to 90 minutes.
    d.
    e. Ordinary Hazard Group 2 Occupancy:
        1) Minimum Design Density: 0.17 gpm over 3,000 sq.ft. area.
        2) Maximum protection area per sprinkler: 130 sq.ft.
        3) Minimum Combined Hose Stream Demand: 250 gpm for 60 to 90 minutes.

D. The criteria listed herein shall not preclude the use of extended coverage or special application fire sprinklers designed and installed in accordance with their listing and manufacturer's instructions.

E. The hydraulic area of operation may not be reduced as allowed by NFPA 13 for areas utilizing quick response sprinklers in unfinished shell spaces. For all other areas, the hydraulic area of operation shall not be reduced as allowed by NFPA 13 for areas utilizing quick response sprinklers unless specifically approved by the Engineer via a formally submitted RFI.

F. Sprinkler spacing shall conform to NFPA 13 and shall not exceed 256 SF per sprinkler in unfinished shell spaces.

G. The hydraulic area of operation shall be increased by 30% without revising the density for areas with sloped ceilings with a pitch exceeding 1 in 6 (16.7% slope) in accordance with NFPA 13.

H. The hydraulic area of operation shall be increased by 30% without revising the density for dry-pipe and double interlock preaction systems in accordance with NFPA 13.

1.04 SUBMITTALS

A. Submit shop drawings prepared in accordance with NFPA 13 as specified in Division 21 Section 210010 "General Fire Suppression Requirements."

B. Contractor to submit engineer approved sprinkler shop drawings to HCA's insuring agency, AIG, for review. Email plans to planreview.americas@aig.com and copy james.dipaoli@aig.com. Anthony's alternate contact information is:

Jamie DiPaoli, PE

99 High Street, 24h Floor, Boston MA 02110

Tel +1 617 457 5847 | Cell +1 862 245 3572

1.05 QUALITY ASSURANCE

A. Contractor shall be responsible for all permits and fees associated with preparation and approval of Drawings and the installation and approval of a fire sprinkler system.

B. Tests and Inspections: Arrange, test, and pay for all tests required by code and authorities having jurisdiction.

1.06 PROJECT CONDITIONS

A. Interruption of Existing Fire Sprinkler Protection: Do not interrupt fire sprinkler system protection to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire sprinkler protection according to requirements indicated:

1. Notify Owner no fewer than five days in advance of proposed interruption of fire-sprinkler protection.
2. Do not proceed with interruption of fire sprinkler protection without Owner's written permission.

1.07 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.08 EXTRA MATERIALS

A. Sprinkler Wrenches: Furnish to Owner, 2 sprinkler wrenches for each type of sprinkler installed.

B. Sprinklers: Furnish extra sprinklers of each style, type and finish included in the project as required by NFPA 13.

C. Sprinkler Cabinet and Wrench: Provide a finished steel cabinet(s), suitable for wall mounting, with hinged cover and space for the quantity of spare sprinklers provided plus sprinkler wrench(es).

D. Provide hydraulic calculation placard attached to each riser.

PART 2 - PRODUCTS AND MATERIALS

2.01 EQUIPMENT

A. All fire protection equipment shall be UL listed for its intended use and in conformance with the applicable NFPA documents.

2.02 PIPE AND FITTING MATERIALS

A. Refer to Division 21 Section 210515 “Basic Fire Suppression Piping Materials and Methods” for specifications on piping and fittings.

2.03 HANGERS

A. Shall be UL listed and shall meet requirements of NFPA 13 for type, dimension and location.

2.04 GENERAL DUTY VALVES

A. Refer to Division 21 Section 210515 “Basic Fire Suppression Piping Materials and Methods” for specifications on general duty valves.

2.05 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by Factory Mutual, approval.
2. Pressure Rating:
   a. Standard Pressure Piping Specialty Valves: 175-psig minimum.
3. Body Material: Cast- or ductile- iron.
4. Size: Same as connected piping.

5. End Connections: Flanged or grooved.

2.06 PIPE FITTINGS

A. Branch Outlet Fittings:
   1. Standard: UL 213.
   2. Pressure Rating: 175-psig minimum.
   3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
   4. Type: Mechanical-T and -cross fittings.
   5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
   6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
   7. Branch Outlets: Grooved, welded or threaded.

B. Flow Detection and Test Assemblies:
   1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, approval.
   2. Pressure Rating: 175-psig minimum.
   3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
   4. Size: Same as connected piping.
   5. Inlet and Outlet: Grooved or threaded.

C. Sprinkler Inspector's Test Fittings:
   1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, approval.
   2. Pressure Rating: 175-psig minimum.
   3. Body Material: Cast- or ductile-iron housing with sight glass.
   4. Size: Same as connected piping.
   5. Inlet and Outlet: Threaded.

2.07 AUTOMATIC SPRINKLERS

A. Sprinklers: type and style as indicated or required by application. Sprinkler operating temperatures to comply with NFPA 13. Sprinklers in Light Hazard areas shall be quick response type.

B. General Requirements:
   1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, approval.
   2. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

C. Automatic Sprinklers with Heat-Responsive Element:
   1. Early-Suppression, Fast-Response Applications: UL 1767.
   2. Nonresidential Applications: UL 199.
   3.
   4. Characteristics: Nominal 1/2-inch orifice with discharge coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Use sprinkler types below for the following applications:
   1. Rooms without Ceilings: Upright sprinklers.
   2. Rooms with Suspended Ceilings: Match Existing.
   3. Rooms with Gypsum Board Ceilings: Match Existing.
   4. Wall Mounting: Sidewall sprinklers.

5. Spaces Subject to Freezing: Dry pendent or dry sidewall sprinklers as indicated on drawings.

E. Provide sprinkler types below with finishes indicated.
   1. Finished Areas:
      a. Concealed Sprinklers: Rough brass, with Match Existing
      b. Recessed Sprinklers: Match Existing
      c. Unfinished Areas: Rough bronze in unfinished spaces not exposed to view.

F. Coordinate sprinkler temperature ratings near heat-producing sources in accordance with NFPA 13.

G. Sprinklers shall be wax coated where exposed to acids, chemicals, or other corrosive fumes.

H. Sprinkler Guards: Provide sprinkler guard where sprinklers are less than 7-feet above finished floor; where subject to physical damage, and/or where indicated on drawings. Guard shall be UL 199 listed, wire cage type with fastening device for attaching to sprinkler.

I. Sprinkler Cabinet and Wrench: Provide a finished steel cabinet, suitable for wall mounting, with hinged cover and space for the appropriate quantity of spare sprinklers plus sprinkler wrench(es).

2.08 ALARM DEVICES

A. Existing to remain. Water Flow Indicators:
   1. Standard: UL 346.
   2. Water-Flow Detector: Electrically supervised.
   3. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory set, field-adjustable retard element to prevent false signals and tamperproof cover.
   4. Type: Paddle operated.
   5. Pressure Rating: 250 psig.
   6. Design Installation: Horizontal or vertical.
   7. Design Operation: Rising pressure signals excessive supervisory air pressure within the system piping, with lowering pressure signals lack of air pressure within the system piping.

B. Valve Supervisory Switches:
   1. Standard: UL 346.
   2. Type: Electrically supervised.
   3. Components: Single-pole, double-throw switch with normally closed contacts and tamperproof cover.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install in accordance with manufacturer’s instructions.

3.02 PREPARATION

A. Perform fire hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

3.03 WATER SUPPLY CONNECTION

A. Connect sprinkler piping to building's interior water distribution piping. Comply with requirements in Division 22 Section 221116 "Domestic Water Piping" for interior piping.

3.04 PIPE APPLICATIONS

A. Piping Above Grade: Refer to Division 21 Section 210515 “Basis Fire Suppression Piping Materials and Methods.”

3.05 PIPING INSTALLATIONS

A. Refer to Division 21 Section 210515“Basic Fire Suppression Piping Materials and Methods” for general fire suppression piping installation requirements.

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

C. Hangers and Supports: Comply with the requirements of NFPA 13. Hanger and support spacing and locations for piping joined with grooved mechanical couplings shall be in accordance with the grooved mechanical coupling manufacturer's written instructions, for rigid systems. Provide protection from damage where subject to earthquake if required by the applicable building code, designed in accordance with NFPA 13. Locate hangers at or directly adjacent to the joist panel points. Provide two nuts on threaded supports to securely fasten the support.

D. Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.

E. Install pressure gauge on the riser or feed main at or near each test connection. Provide pressure gauge with a connection not less than 1/4 inch and having a soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they will not be subject to freezing.

F. Fill wet-type sprinkler system piping with water.

G. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 21 Section 210515 "Basic Fire Suppression Piping Materials and Methods"

H. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 21 Section 210515 "Basic Fire Suppression Piping Materials and Methods."

3.06 PIPE JOINT CONSTRUCTION

A. Refer to Division 21 Section 210515 “Basic Fire Suppression Piping Materials and Methods” for general pipe joint construction requirements.

3.07 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

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

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable water supply sources.

3.08 SPRINKLER INSTALLATIONS

A. Use proper tools to prevent damage during installations.

B. Areas with ceilings: Install sprinklers not less than 6-inches from the edge of a ceiling tile in areas with suspended ceilings, in a symmetrical pattern with lights and outlets.

C. Install sprinklers in a symmetrical pattern with lights and outlets in all other areas with ceilings.

D. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

E. Do not install more than one sprinkler on a one inch outlet unless hydraulic calculations are included to verify performance.

3.09 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and Division 21 Section 210553 “Identification for Fire Suppression Piping and Equipment.”

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

A. Perform required tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, “Systems Acceptance” Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire alarm tests. Operate as required.
6. Verify that equipment hose threads are same as local fire department equipment.

C. Replace piping system components that do not pass the test procedures specified, and retest repaired portion of the system.

3.11 CLEANING

A. Clean dirt and debris from sprinklers.

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

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.13 COMMISSIONING

A. Sprinkler Systems: Test per NFPA 13, NFPA 25 and local authorities requirements. Submit Contractor’s Material & Test Certificates for Above Ground Piping. Submit certificates of completion to Authority Having Jurisdiction and Owner.

1. After completion of all installation, tests, etc., and prior to the opening date, the Sprinkler Subcontractor shall instruct the building personnel in the operation of the sprinkler system. Special care shall be taken to make sure the building personnel:
   a. Will immediately recognize whether the system control valves are in an ‘Open’ position or a ‘Closed’ position.
   b. Will know how to drain the system.
   c. Will know how to test the flow switches, tamper switches and alarm system.
   d. Will know how to make complete weekly inspection.
   e. Will know how to perform periodic maintenance of the Fire Sprinkler System.

B. Fire Alarm Equipment: Test per NFPA 25, NFPA 72 and local authorities requirements in the presence of the Owner. Submit certificates of completion to authority having jurisdiction and Owner.

END OF SECTION 21 13 13

SECTION
GENERAL PLUMBING REQUIREMENTS

PART 1 - GENERAL REQUIREMENTS

1.01 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.

1.02 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.

1.03 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:

UPC	Uniform Plumbing Code – 2018
IECC	International Energy Conservation Code
ADA	American Disabilities Act
AIA	Guidelines for Design and Construction of Hospital and Healthcare Facilities
AMCA	Air Movement and Control Association, Inc.
ANSI	American National Standards 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
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.

1.04 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.

1.05 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.

1.06 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.

1.07 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.

1.08 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF 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. Contact the Architect for Architect's written authorization. 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. In addition to payment, Architect's written authorization and Engineer's release agreement form must be received before electronic drawing files will be sent.

1.09 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.

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. Use of explosives is not permitted.

E. 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 - NOT USED

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 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.

3.04 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.

3.05 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.

3.06 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. Refer to Table 4 at the end of this section for a list of specification sections in Division 22 that contain special inspection requirements.
   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, 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 22 00 10

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
220515	Basic Piping Materials And Methods	B, G
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
221300	Sanitary Drainage & Vent Piping & Specialties	B
224000	Plumbing Fixtures	B, E, N
226100	Gas & Vacuum Systems For Medical Facilities	B, C, E, F, G

CODED LEGEND

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

TABLE 2: SPARE PARTS REQUIREMENTS FOR PLUMBING EQUIPMENT

Section Number		Received/Date/Initial
220553	Identification For Plumbing Piping & Equipment	_____
221100	Water Distribution Piping & Specialties	_____
224000	Plumbing Fixtures	_____
22610	Gas & Vacuum Systems For Medical Facilities	_____

_____
Owner's Signature

TABLE 3: SPECIAL WARRANTY REQUIREMENTS FOR PLUMBING EQUIPMENT

Section Number	Received/Date/Initial

TABLE 4: SPECIAL INSPECTION REQUIREMENTS FOR PLUMBING EQUIPMENT

Section Number		Completed/Date/Initial
226100	Gas & Vacuum Systems For Medical Facilities	_____

TABLE 5: PLUMBING SPECIFICATION OPERATION AND MAINTENANCE SUBMITTAL REQUIREMENTS

SPECIFICATION NUMBER/TITLE		CODE DESIGNATION
220500	Common Work Results For Plumbing	B
220515	Basic Piping Materials And Methods	B
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
221300	Sanitary Drainage & Vent Piping & Specialties	A, B, F
224000	Plumbing Fixtures	B, E, H, I
226100	Gas & Vacuum Systems For Medical Facilities	A, B, C, D, E, G, H, I

CODED LEGEND

A	As-Built Drawings	E	Operating Instructions
B	Product Data	F	Test Reports
C	Performance Data, Capacities, Curves and Certificates	G	Warranties
		H	Recommended Spare Parts List
D	Wiring Diagrams	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 22 00 15
COORDINATION

PART 1 - GENERAL REQUIREMENTS

1.01 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.

1.02 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.

1.03 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

2.01 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

3.01 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
Loose motor starters, disconnect switches, thermal overloads and heaters.	DIV 26	DIV 26	DIV 26	DIV 23
Factory assembled control panels	DIV 22	DIV 26	DIV 26	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 22 00 15

SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL REQUIREMENTS

1.01 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.

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.

1.02 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.

1.03 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.

1.04 NOISE CRITICAL SPACES

A. Many areas of the building, referred to as "noise-critical spaces", require special attention (special acoustical provisions and restrictions). The table below designates the noise-critical spaces; noise levels due to equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall permit attaining sound pressure levels in all 8 octave bands in occupied spaces conforming to RC levels per ASHRAE handbook as indicated.

Space	RC Levels
Teleconference Rooms	25
Conference Rooms	30

PART 2 - PRODUCTS AND MATERIALS

2.01 ACCESS TO EQUIPMENT

A. 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.
9. Locking Devices: Where indicated on the drawings or where access panels are installed in locations accessible to the public, provide 5-pin or 5-disc type cylinder locks, individually keyed; provide 2 keys.

2.02 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.

2.03 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.

2.04 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.

C. Leak Detection System: Rope style leak sensor and controller capable of connecting to a building automation system with audible and visual alarms for leak detection in all drip pans unless otherwise noted on drawings. Provide with factory 24V DC power supply with power plug, sensing cables, and accessories.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. RLE Technologies #LD1000

2.05 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.

2.06 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.

2.07 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. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
    1. Architectural Sealants: 250 g/L.
    2. Sealant Primers for Nonporous Substrates: 250 g/L.
    3. Sealant Primers for Porous Substrates: 775 g/L.

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

D. 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.

E. 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.

2.08 ACOUSTICAL SEALANTS

A. General: Penetrations by pipes through surfaces that are around and between noise critical spaces shall be sleeved, packed and sealed airtight with foam rod, non-hardening sealant and/or packing material as described herein.

B. Foam Rod: Foam backer rod shall be closed cell polyethylene suitable for use as a backing for non-hardening sealant.

C. Non-Hardening Sealant: Sealant for penetrations shall be non-hardening polysulphide type. Permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

D. Packing Material: Mineral fiber; non-combustible; resistant to water, mildew and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 15 pcf (40 kg/m3).

2.09 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.

2.10 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

3.01 INSTALLATION, GENERAL

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

3.02 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.

3.03 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."

3.04 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.

3.05 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.

3.06 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.

3.07 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.

K. All openings sleeved through underground exterior walls shall be sealed with mechanical sleeve seals as specified in Division 22 Section “Basic Piping Materials and Methods”.

3.08 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.

F. Install leak detection rope in a zig-zag pattern covering entire length and width of the drip pan. Secure rope to pan per manufacturers recommendations.

G. Mount leak detection controller on wall adjacent to exit of the room above which the drip pan is located unless otherwise indicated on drawings indicated on drawings.

H. Coordinate disconnect and power supply for leak detection system and 120V dedicated receptacle adjacent to controller with Division 26. Power wiring and receptacles are specified in Division 26 Section “Common Work Results for Electrical” Disconnects are specified in Division 26 Section “Enclosed Switches and Circuit Breakers”

I. Coordinate interlock of “Water Present” alarm and “Cable Fault” alarm with Building Automation System. Refer to Division 23 Section “Direct Digital Controls for HVAC” for integration with building automation system and low voltage power wiring.

J. Interlock control panel with relay at motorized ball valve actuator. Upon receiving leak alarm signal the control panel shall energize motorized ball valve “MBV” to close. Motorized ball valve “MBV” is indicated and specified on the drawings. Relays are provided by electrical.

3.09 ACOUSTICAL PENETRATIONS

A. General: There shall be no direct contact of piping with shaft walls, floor slabs and/or partition. All openings around pipes in the structure surrounding the plumbing equipment and surrounding noise-critical spaces shall be sealed, packed with caulking for the full depth of the penetration, as described herein. This includes all slab penetrations and penetrations of noise critical walls.

B. Domestic Water, Sewer, Drain and Vent Piping

1. Where a pipe passes through a wall, ceiling or floor slab of a noise critical space, a steel sleeve shall be cast or grouted into the structure. The internal diameter of the sleeve shall be 2 inches larger than the external diameter of the pipe passing through it. After all of the piping is installed in that area, the Contractor shall check the clearance and correct it, if

necessary, to within 1/2 inch. Pack the void full depth with packing material sealed at both ends, 1 inch deep, with non-hardening sealant backed by foam rod.

END OF SECTION 22 05 00

SECTION 22 05 15
BASIC PIPING MATERIALS AND METHODS

PART 1 - GENERAL REQUIREMENTS

1.01 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.

1.02 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.

1.03 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
3. Wall Pipes
4. 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.

1.04 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

2.01 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 Unions:
   a. JOMAR International
   b. Smith Cooper International
   c. Watts Regulator Co.
   d. Zurn Industries
3. 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.
   j.
4. 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.

2.02 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.

2.03 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.

2.04 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. 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.

E. Sleeves:

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

2.05 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

3.01 INSTALLATION, GENERAL

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

3.02 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.

3.03 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.

3.04 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.

3.05 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 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.

E. 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.

F. Acoustical Barrier Penetrations: Where a pipe passes through a wall, ceiling or floor slab of a noise critical space, a steel sleeve shall be cast or grouted into the structure. Refer to Section “Basic Mechanical Materials and Methods” for noise critical spaces. The internal diameter of the sleeve shall be a minimum of 2 inches larger than the external diameter of the pipe. After the piping is installed, the Contractor shall check the clearance and correct it to within 1/2-inch. Contractor shall pack the void full depth with glass/mineral fiber insulation and seal at both ends, 1-inch deep, with sealant backed by foam rod.
   1. Penetration of sound isolating ceilings by sprinkler pipes and heads shall be sleeved and sealed and shall have no rigid connections between them.

3.06 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, compressed air, vacuum) for copper or brass connected to carbon steel, cast or ductile iron.

H. 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 wet piping systems (water) (except do not

install dielectric unions in concealed spaces, instead, install dielectric waterway fittings) for copper or brass connected to carbon steel, cast or ductile iron.

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

J. 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.

K. 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.

3.07 JOINTS

A. 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.

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

3.08 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 22 05 15

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 22 05 16
EXPANSION FITTINGS AND LOOPS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes the following:
   1. Flexible expansion loops
   2. Piped expansion loops

B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Division 22 Section “Hangers and Supports for Plumbing Piping”, for pipe anchors and alignment guides.
   2. Division 22 Section “Sanitary Drainage and Vent Piping and Specialties” for shielded transition couplings.

1.02 DEFINITIONS

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

B. 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.

1.03 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
   1. Product data for each type of pipe expansion joints specified. Submit expansion compensation schedule showing manufacturer's figure number, size, location, connections, material and displacement for each required expansion joint.
   2. Assembly-type shop drawings for each type of expansion compensation product, indicating dimensions, weights, required clearances, and methods of assembly of components. Detail fabrication of pipe anchors, hangers, special pipe support assemblies and their attachment to the building structure. Submit calculations of pipe expansion forces at anchor points for structural engineer review.
   3. Shop drawings for field-fabricated expansion loops indicating location, dimensions, pipe sizes, calculations for compression or tension required, and location. Detail fabrication of pipe anchors, hangers, special pipe support assemblies and their attachment to the building structure. Submit calculations of pipe expansion forces at anchor points for structural engineer review.
   4. Maintenance data for expansion joints for inclusion in Operating and Maintenance Manuals specified in Division 1 and Division 22 Section "General Plumbing Requirements."
   5. Submit certification that expansion joints for domestic water distribution for drinking or cooking comply with NSF 61 Annex G and / or NSF 372.
   6. Submit American Gas Association certification for expansion joints used for natural gas distribution systems.

1.04 QUALITY ASSURANCE

A. 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.

B. 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.

C. Expansion joints 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

2.01 MANUFACTURERS

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

1. Flexible Expansion Loops:
    a. Flex-Hose Co. Inc.
    b. Flexicraft Industries
    c. Keflex HVAC Products, Flex-Weld, Inc.
    d. Metraflex Co.
    e. Twin City Hose
2. Packless Rubber Expansion Joints:
    a. Flexider USA
    b. Garlock Mechanical Packing Div., Colt Industries
    c. Holz Rubber
    d. Keflex HVAC Products Div., Flex-Weld, Inc.
    e. MG Piping Products Co.
    f. Mason Industries, Inc.
    g. Metraflex Co.
    h. Vibration Mountings and Controls, Subsidiary of ARX.

2.02 PIPE EXPANSION JOINTS, GENERAL

A. Pipe expansion joints shall provide 200 percent absorption capacity of piping expansion between anchors.

B. Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

C. Fittings: Materials of construction and end fitting type shall be consistent with pipe material and equipment / pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.

2.03 FLEXIBLE EXPANSION LOOPS

A. Expansion Compensators for domestic distribution water systems: Flexible loops shall consist of two lead free copper 90 degree elbows and one lead free copper 180 degree return assembly, such that the piping does not change direction and maintains course along a single axis. Provide with support nut at the bottom of the 180 degree return assembly for proper positioning, drain plug, and lead free bronze flexible hose and braid. Provide copper sweat ends for 2” and smaller and lead free bronze 150# flanges for 2-1/2” and larger. Units shall be minimum cold working pressure 150 psi. [Units shall be listed and labeled for UPC.]

B. Expansion Compensators for natural gas distribution systems: Flexible loops shall consist of two carbon steel 90 degree elbows and one carbon steel 180 degree return assembly, such that the piping does not change direction and maintains course along a single axis. Provide with support nut at the bottom of the 180 degree return assembly for proper positioning, drain plug, and stainless steel hose and braid. Provide threaded ends for 2” and smaller and steel 150#

flanges for 2-1/2" and larger. Units shall be cold working pressure 150 psi. Unit shall be specifically designed for natural gas systems and bear the AGA stamp.

C. Rubber Expansion Joints: Fabric-reinforced EPDM rubber with full-faced integral flanges, external control rods and shall be internally reinforced with steel retaining rings over entire surface of flanges, drilled to match flange bolt holes.

2.04 FLEXIBLE BALL PIPE JOINTS

2.05 EXPANSION LOOPS

A. Provide pipe expansion loop constructed of main pipe material. Acceptable methods include use of elbows in a U or Z shape as defined by ASHRAE or ASME; or a detailed stress analysis may be utilized to define areas of expansion.

2.06 ALIGNMENT GUIDES AND ANCHORS

A. Provide alignment guides and anchors as specified in specification Division 22 Section "Hangers and Supports for Plumbing Piping".

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

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

B. Install expansion joints and expansion loops where indicated on the drawings and where required for adequate expansion of installed piping system.

C. Install expansion loops in all piping crossing building expansion joints. Expansion loops shall be sized to meet or exceed building expansion as defined in the structural documents. Expansion loops shall be capable of moving in all planes. Provide hangers and supports per manufacturer's instructions.

D. Anchor piping to ensure proper direction of expansion and contraction

E. Align joints to avoid end loading and torsional stress.

3.02 FLEXIBLE EXPANSION LOOPS

A. Install loops at locations indicated on plans. Amount of expansion shall be as indicated on plans. Support loop as required by manufacturer and to prevent binding or sagging per Division 22 Section "Hangers and Supports for Plumbing Piping".

B. Where required by manufacturer provide hanger or support for 180 degree return fitting.

C. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.

3.03 EXPANSION LOOPS

A. Fabricate expansion loops to dimensions indicated. For thermal expansion loops subject loop to cold spring tension or compression necessary to absorb 50 percent of the total compression or tension during anticipated change in temperature.

B. Expansion loop locations and dimensions shall be based on routing shown on plans. If routing is modified, coordinate locations with engineer.

C. Fabricate expansion loops to dimensions indicated on plans.

D. For thermal expansion loops, install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature. After installation remove temporary space holders as required.

E. Provide hangers and supports in accordance with Division 22 Section "Hangers and Supports for Plumbing Piping". For expansion loops with horizontal and vertical components, support for the horizontal legs shall be designed for full weight of the pipe with maximum load variation of 25%.

F. Provide alignment guides at locations indicated on plans and as required for piping expansion. At a minimum, install alignment guides on both sides of expansion loop, spaced at twice the

height of the U or Z loop (height defined as perpendicular distance of piping from primary pipe direction) or as required by the expansion joint manufacturer. Alignment shall be sufficient to allow for proper installation of expansion joints to prevent binding or torsional stress on joint.

G. Provide anchors at locations indicated on plans and as required for piping expansion. At a minimum install anchors on both sides of straight pipe length incorporating expansion loop.

H. For gravity drainage systems and vent systems, connect plain end expansion compensators to hubless cast iron with shielded transition couplings. Shielded transition couplings are specified in Division 22 Section “Sanitary Drainage and Vent Piping and Specialties”.

END OF SECTION 22 05 16

SECTION 22 05 23
GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes general duty valves common to most mechanical piping systems.

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

1.02 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.

1.03 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.

1.04 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 various MSS Standard Practices referenced.

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

2.01 MANUFACTURERS

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

2.02 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, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10 plug valves.

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

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

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

1. Threads: Comply with ANSI B1.20.1.

2. 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.

2.03 GATE VALVES

A. Lead Free Gate Valves, 2-Inch and Smaller: Meeting MSS SP-80; Class 125, 200-psi CWP, body, solid wedge and bonnet of ASTM B 584 lead free cast bronze; brass packing gland and stem of ASTM B283 naval brass; with solder ends, non-asbestos composition packing, and malleable iron handwheel.

2.04 BALL VALVES

A. Lead Free 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, with replaceable "Teflon" or "TFE" seats and seals, solder ends and vinyl-covered steel handle.

2.05 CHECK VALVES

A. Lead Free 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. Lead Free Lift Check Valves, 2-Inch and Smaller: Meeting MSS SP-80; Class 125, 300-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

3.01 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.

3.02 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

A. VALVES, 2-INCH AND SMALLER

SERVICE	GATE	BALL	CHECK
Domestic Hot and Cold Water	125	150	125

3.03 VALVE SCHEDULE

A. Lead Free Gate Valves - 2 Inch and Smaller, Class 125:

MANUFACTURER	SOLDER NRS
Apollo	102S-LF
Hammond	UP-668
Milwaukee	UP668
NIBCO	S-113-LF

B. Lead Free 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

C. Lead Free Swing Check Valves – 2 inch and smaller, Class 125:

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

D. Lead Free Lift Check Valves – 2 inch and smaller, Class 150:

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

3.04 APPLICATION SCHEDULE

A. General Application: Use gate, 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. Gate Valves: Class 125, NSF 61 Annex G lead free cast bronze or cast-iron body to suit piping system.
2. Ball Valves, 2” And Smaller: Class 150, 600-psi CWP, with stem extension, NSF 61 Annex G lead free cast bronze.
3. Bronze Swing Check: Class 125, NSF 61 Annex Glead free cast bronze, with rubber seat.
4. Check Valves: Class 125, swing or wafer type as indicated.

3.05 VALVE INSTALLATIONS

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

B. 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.

C. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

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:

1. Swing Check Valves: Horizontal position with hinge pin level.
2. Lift Check Valve: With stem upright and plumb.

3.06 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.

3.07 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 22 05 23

SECTION
HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 - GENERAL REQUIREMENTS

1.01 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. Pipe alignment guides.
   9. Anchors.

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.

1.02 DEFINITIONS

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

1.03 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.

1.04 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

2.01 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. Midwest.
9. National Pipe Hanger Corporation.
10. Power-Strut.
11. Truscon.
12. 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-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.

2.02 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.
3. Components as listed below shall be made of 304 stainless steel where indicated.

2.03 SHIELDS

A. 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.

B. 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.

C. 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.

2.04 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.

2.05 PIPE ALIGNMENT GUIDES

A. Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

2.06 EXPANSION ANCHORS

A. Self drilling, drilled flush or shell type.

2.07 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

3.01 INSTALLATION, GENERAL

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

3.02 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.

3.03 INSTALLATION OF PIPE ALIGNMENT GUIDES

A. Install pipe alignment guides on piping that adjoins expansion joints, as required by expansion joint manufacturer, and elsewhere as indicated on plans and specification sections to eliminate binding and torsional stress on piping systems. Install guides per ASME B31.9 unless noted otherwise.

B. Anchor to building substrate.

3.04 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.

3.05 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.

3.06 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.

3.07 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 22 05 29

SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL REQUIREMENTS

1.01 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. Valve Tags
4. Valve Schedule Frames
5. Engraved Plastic-Laminate Signs
6. Plastic Equipment Markers
7. Plasticized Tags

1.02 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.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Samples: Submit samples of each color, lettering style and other graphic representation required for each identification material or system.

C. 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.

D. Maintenance Data: Include product data and schedules in Maintenance Manuals as specified in Division 1 and Section “General Plumbing Requirements.”

1.04 SPARE PARTS

A. Furnish minimum of 5% extra stock of each plumbing identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

PART 2 - PRODUCTS AND MATERIALS

2.01 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. Industrial Safety Supply Co., Inc.
4. Seton Name Plate Corp.

2.02 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.

2.03 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.

G. Lettering: Manufacturer's standard pre-printed nomenclature which best describes piping system in each instance, as selected by Architect/Engineer in cases of variance with names as shown or specified.

2.04 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.

2.05 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.

C. 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.

2.06 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.

2.07 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, complying with ASTM D 709, 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. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.08 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, dampers, and valves; and 4-1/2" x 6" for equipment.

2.09 PLASTICIZED TAGS

A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing. Tags shall be minimum 3-1/4" x 5-5/8" in size, provided with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

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

3.01 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.

3.02 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. Medical gas piping (indicate each type of system, accordingly).

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.

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.

3.03 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 and lawn-watering 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.

3.04 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. Heat exchangers
5. Water heaters, tanks and pressure vessels.
6. 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: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 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.

1. Optional Use of Plasticized Tags: At Installer's option, where equipment to be identified is concealed above acoustical ceilings or similar concealment, plasticized tags may be installed within concealed space to reduce amount of text in exposed sign (outside concealment).
2. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at Installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

END OF SECTION 22 05 53

SECTION 22 07 00
PLUMBING INSULATION

PART 1 - GENERAL REQUIREMENTS

1.01 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

1.02 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: Outdoor Plumbing insulation may have flame spread index of 75 and smoke developed index of 150.
2. 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.

1.03 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

2.01 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

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

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

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. Calcium Silicate: ASTM C533 and C795.

2.03 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

3.01 INSTALLATION, GENERAL

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

3.02 PLUMBING PIPING SYSTEM INSULATION

A. Insulation Omitted: Omit insulation on the following:

1. Chrome-plated exposed piping
2. Water Hammer Arrestors
3. Balancing and flow valves
4. Drain lines from water coolers
5. Exterior condensate drain piping
6. 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.

c. Hot drain piping (where indicated).

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.

3.03 EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment:

a. Drip pans under chilled equipment.

b. 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.

3.04 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. Provide high density insulation material under supports or pre-insulated supports for cold piping. Protect insulation with shields to prevent puncture or other damage. Refer to Division 22 Section “Hangers and Supports for Plumbing Piping” for pre-insulated supports and insulation shields.
   1. Insulation material shall extend a minimum 2 inches past the pipe shield on each side.

G. Provide pipe hangers for hot piping sized for the outside diameter of piping. Butt insulation to hanger or riser clamp for vertical pipe. Butt pipe insulation tightly at insulation joints. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

H. 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.

I. 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.

J. 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.

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

3.05 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 boiler manholes, handholes, 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.

3.06 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.

3.07 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 22 07 00

SECTION 22 11 00
WATER DISTRIBUTION PIPING AND SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

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

1. Division 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
2. Division 22 Section "Identification, for Plumbing Piping and Equipment" for labeling and identification of water distribution piping.
3. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations, wall penetrations and equipment pads.
4. 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.
5. Division 22 Section "General Duty Valves for Plumbing Piping," for materials and methods for installing water distribution piping valves.
6. Division 22 Section "Hangers and Supports for Plumbing Piping," for insulation shields, materials and methods for hanging and supporting water distribution piping.
7. Division 22 Section "Plumbing Insulation," for materials and methods for insulating water distribution piping.
8. Division 22 Section “Sanitary Drainage and Vent Piping and Specialties,” for material and methods for trap primer outlet piping.

1.02 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.

1.03 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. Wall, yard and roof hydrants
    b. Emergency mixing valves

1.04 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.

1.05 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

2.01 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. Wall/Yard Hydrants:
        a. Josam Co.
        b. Smith (Jay R.) Mfg. Co.
        c. Prier, Inc.
        d. Tyler Pipe/Wade Div.; Subs. of Tyler Corp.
        e. Watts Drainage
        f. Woodford Mfg. Co.
        g. Zurn Industries Inc., Hydromechanics Div.
    3. Backflow Preventers:
        a. Cla-Val Co.
        b. Conbraco Industries, Inc.
        c. Febco
        d. Hersey Products, Inc.
        e. Watts Regulator Co.
        f. Zurn Industries Inc. Wilkins Regulator Div.

4. 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.
5. Point of Use Thermostatic Mixing Valves
    a. Acorn Engineering Co.
    b. Cash Acme
    c. Leonard Valve Co.
    d. Powers Process Controls
6. Emergency Mixing Valves
    a. Acorn Engineering Co.
    b. Bradley
    c. Haws Corp.
    d. Lawler Manufacturing Co., Inc.
    e. Leonard Valve Co.
    f. Stingray Systems
7. Trap Primers and Distribution Units
    a. PROFLO
8. Plumbing Pipe Support Brackets
    a. PROFLO
9. Tube Suspension Clamps
    a. PROFLO
10. Roof Hydrants
    a. Mapa
    b. Woodford Mfg. Co.
    c. Prier, Inc.

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

2.03 FITTINGS

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

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

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

D.

2.04 JOINING MATERIALS

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

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

2.05 GENERAL-DUTY VALVES

A. General-duty valves (i.e., gate, globe, 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.

2.06 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.

2.07 PIPING SPECIALTIES

A. 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.

B. Roof Hydrants: As specified on the drawings.

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

D. 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.

E. 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.

F. 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.

G. Trap Primers: Brass construction, line pressure operation, capacity to prime number of traps as indicated with distribution units complying with requirements of ASSE Standard 1018.

H. 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.

I. 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.

3.02 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.

3.03 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. 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.

K. Install piping level with no pitch.

3.04 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 “Mechanical 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.	Steel Pipe Max. Span - Ft.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.
Up to 3/4	7	5	3/8
1	7	6	3/8
1-1/4	7	7	3/8
1-1/2	9	8	3/8
2	10	8	3/8
2-1/2	11	9	1/2
3	12	10	1/2
3-1/2	13	11	1/2
4	14	12	5/8 (1/2 for copper)
5	16	13	5/8 (1/2 for copper)
6	17	14	3/4 (5/8 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.

3.05 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. Joints Containing Dissimilar Metals: Provide dielectric unions for 2” and smaller and dielectric flanges for piping 2-1/2” and larger. Provide dielectric waterway fittings for 2” and smaller in concealed locations. Dielectric unions, waterway fittings and flanges are specified in Section “Basic Piping Materials and Methods”.

E. 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”.

3.06 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 gate, ball, and butterfly valves.

B. Throttling duty: Use globe, ball, and butterfly valves.

3.07 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 gate or ball valves; for sectional valves 2-1/2 inches and larger, use ball, gate 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 gate or ball valves; for shutoff valves 2-1/2 inches and larger, use ball, gate or butterfly valves.

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 gate or ball valves; for drain valves 2-1/2 inches and larger, use ball, gate or butterfly valves.

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

E. 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.

F. 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 facuet."

3.08 INSTALLATION OF FLOW CONTROL VALVES

A. Install flow control valves or 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 flow control or automatic flow control valve.

B. Set flow control valve flow rate as follows:

1. Preliminary Procedures For Hot Water Return System Balancing:
    a. Before operating the system perform these steps:
        1) Open valves at recirculation pump and flow control valves to full open position.
        2) Remove and clean all strainers.
        3) Check recirculation pump rotation.
        4) Set water heater temperature as indicated on the drawings.
2. Procedures For Hot Water Return System Balancing
    a. Refer to the drawings for required flow rate for each flow control valve.
    b. Provide required instrumentation to obtain proper measurements. Instruments shall be properly maintained and protected against damage.
    c. Apply instrument as recommended by the manufacturer.
    d. Take readings with the eye at the level of the indicated value to prevent parallax.
    e. Mark flow control valve setting with memory stop. Mark with paint or other suitable, permanent identification materials.
    f. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

C. 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.

3.09 TRAP PRIMERS

A. Install trap primers where indicated and where required by local authorities having jurisdiction.

B. Connect trap primer supply line to the top of domestic cold water line no larger than 1 ½" in diameter.

C. Provide trap primer distribution units for trap primers serving more than one trap.

D. Install trap primer distribution level to insure even water distribution unit to each circuit.

E. Where applicable, adjust the trap primer for proper flow.

F. Install trap primers a minimum of 12 inches above finished floor for every 20 feet of horizontal outlet piping to floor drains served.

G. Install trap primers in an accessible location.

H. Refer to Division 22 Section “Sanitary Drainage and Vent Piping and Specialties” for trap primer outlet pipe requirements.

3.10 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. 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.

3.11 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.

3.12 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.

3.13 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.

3.14 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 22 11 00

SECTION 22 13 00
SANITARY DRAINAGE AND VENT PIPING AND SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.01 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 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
3. Division 22 Section "Plumbing Identification," for labeling and identification of drainage and vent piping.
4. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations, wall and floor penetrations and equipment pads
5. Division 22 Section "Basic Piping Material and Methods," for materials and methods for mechanical sleeve seals.
6. Division 22 Section "Hangers and Supports for Plumbing Piping," for materials and methods for hanging and supporting drainage and vent piping.
7. Division 22 Section "Plumbing Insulation," for materials and methods for insulating drainage piping.
8. Division 22 Section “Water Distribution Piping and Specialties,” for material and methods for trap primers and trap primer inlet piping.

1.02 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.

1.03 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
4. Trench drains
5. Interceptors
6. No-hub fitting restraints

C. Test reports specified in Part 3 of this Section.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following codes:
   1. 2018 International Plumbing Code

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Drainage Piping Specialties, including cleanouts, 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.
   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. Trap Seals
      a. Jay R. Smith Mfg. Co.
      b. MIFAB
      c. Proset Systems “Trap Guard”
      d. Sure Seal, Inc.
      e. Zurn Industries, Inc.; Hydromechanics Div.
   6. Hubless Couplings:
      a. Anaco
      b. Ideal Tridon
      c. Mission Rubber Company
      d. ProFlo “PFNH”
      e. Tyler Pipe / Soil Pipe Division
   7. No-Hub Fitting Restraints
      a. Holdrite

2.02 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. Shielded Transition Couplings: ASTM C1460 with neoprene adapter gasket with stainless steel Shield and hose clamps.

2.03 DRAINAGE PIPING SPECIALTIES

A. Cleanout Plugs: As specified on the drawings.
   a. Floor Cleanouts: As specified on the drawings.

B. Wall Cleanouts: As specified on the drawings.

C. Floor Drains: As specified on the drawings.

D. 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.

2.04 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

3.01 INSTALLATION, GENERAL

A. Install pipe and specialties in accordance with manufacturer’s installation instructions.

3.02 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, and kitchen equipment to cast iron drainage piping.

C. Install Type M copper tube with wrought copper fittings with solder joints, 1” and smaller, with ¾” minimum size and install Type DWV copper tube with cast copper alloy solder joint drainage fittings (DWV) fittings for 1-1/4” and larger for waste connections from kitchen equipment and terminate over floor receptors with air gap.

D. Install ½” type L copper tube for trap primer outlet piping.

3.03 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 soil, waste and 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.
3. 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 soil and waste 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.

3.04 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. Paint exposed copper drain lines serving kitchen equipment with a minimum of two coats of chromium-base paint.

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. 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. 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.

K. 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.

3.05 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.

C. Install hangers at the following intervals and provide rods of diameter as listed below:

Nom. Pipe Size In Inches	Steel Pipe Max. Span In Feet	Copper Tube Max. Span. In Feet	Min. Rod Dia. - Inches Steel or Cast Iron	Min. Rod Dia. – Inches Copper or PVC
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
8	19	16	7/8	3/4
10	22	18	7/8	3/4
12	23	19	7/8	3/4

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.

3.06 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.

B. Cleanout Covers: Install floor and wall cleanout covers for concealed piping, types as indicated.

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.

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.

3.07 INSTALLATION OF FLOOR DRAINS, FLOOR SINKS AND FLOOR TROUGHS

A. Install floor drains, floor sinks and floor troughs 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. Set floor sinks and floor troughs flush with the level finish floor.

C. Refer to architectural documents for floor slope requirements and set floor drain elevation to match. Where architectural documents do not indicate the requirements, set the floor drain elevation depressed below the finished slab elevation as listed below to provide proper slope to drain:

DEPRESSION IN INCHES	RADIUS OF AREA DRAINED - FEET
1/2	5
3/4	10
1	15
1-1/4	20
1-1/2	25

D. Provide P-traps for drains connected to the sanitary sewer.

E. Install floor drains, floor sinks and floor troughs in 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.

3.08 INSTALLATION OF TRAP PRIMERS

A. Install trap primer outlet piping with 1/32" per foot slope towards drain trap where possible.

B. Connect trap primer outlet piping only to factory installed taps on the drain body or P-trap assembly or provide an auxiliary inlet fitting with factory installed trap primer tap.

C. Install trap primer outlet piping in elevated slabs or slabs on grade below concrete reinforcing bars. Wrap with ½" thick flexible unicellular insulation, attach to the reinforcing bars with plastic ties and spacers every five feet to eliminate galvanic corrosion. Refer to Division 22 Section "Plumbing Insulation" for flexible unicellular insulation.

D. Where proper trap primer outlet piping slope can be maintained and the trap primer outlet line would not be subject to freezing, trap primer outlet lines may be installed as follows:

1. Install below elevated floor slabs.

2. Install in the sub grade of slab on grade.

E. Install sleeves and caulk at penetrations through building floor for watertight installation. In an elevated floor slab installation, bracket the piping to bottom of floor once the slab is poured.

F. Refer to Division 22 Section “Water Distribution Piping and Specialties” for trap primer and trap primer inlet pipe requirements.

3.09 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.

3.10 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.

3.11 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 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 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, 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.

3.12 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.

3.13 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 22 13 00

SECTION 22 14 00
STORM DRAINAGE PIPING AND SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.01 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 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers.
4. Division 22 Section "Identification for Plumbing Piping and Equipment," for labeling and identification of drainage piping.
5. Division 22 Section "Common Work Results for Plumbing," for materials and methods for fire barrier penetrations, wall and floor penetrations and equipment pads
6. Division 22 Section "Basic Piping Material and Methods," for materials and methods for mechanical sleeve seals.
7. Division 22 Section "Hangers and Supports for Plumbing Piping," for materials and methods for hanging and supporting drainage piping.
8. Division 22 Section "Plumbing Insulation," for materials and methods for insulating drainage piping.

1.02 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.

1.03 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. Area drains
4. Roof drains
5. No-hub fitting restraints

C. Test reports specified in Part 3 of this Section.

1.04 QUALITY ASSURANCE

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

1. 2018 International Plumbing Code

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

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

1. Drainage Piping Specialties, including backwater valves, expansion joints, cleanouts, area/roof drains, cast-iron trench 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.
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. 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. No-Hub Fitting Restraints
    a. Holdrite
7. PVC DWV Expansion Joints
    a. Charlotte Pipe and Foundry Company #133
    b. Spears Manufacturing Company #S119

2.02 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 CIPSI and NSF.

1. Heavy duty couplings and compression gaskets: ASTM C1540 and meeting FM 1680.

B. 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. Fittings 16” and larger shall be fabricated type.
2. Solvent: ASTM D2564.

C. Shielded Transition Couplings: ASTM C1460 with neoprene adapter gasket with stainless steel Shield and hose clamps.

2.03 UNDERGROUND BUILDING DRAIN PIPE AND FITTINGS

A. Cast-Iron Soil Pipe: ASTM A74, Service weight, hub-and-spigot soil pipe and fittings, and bearing the trademark of CIPSI and NSF. Pipe and fittings shall have a heavy coating of coal tar varnish or asphaltum on both inside and outside surfaces.

1. Neoprene Compression Gaskets: ASTM C564.

B. 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.

C. Underground Shielded Adapter Couplings: ASTM C1173 with neoprene adapter gasket with stainless steel shield and stainless steel hose clamps.

2.04 DRAINAGE PIPING SPECIALTIES

A. Expansion Joints: Cast-iron body with adjustable bronze sleeve, bronze bolts with wing nuts.

B. Cleanout Plugs: As specified on the drawings.

a. Floor Cleanouts: As specified on the drawings.

C. Wall Cleanouts: As specified on the drawings.

D. Area drains: As specified on the drawings.

E. Roof Drains: As specified on the drawings.

F. PVC DWV Expansion Joints: Schedule 40 PVC DWV meeting ASTM D2665 with socket connections and telescoping expansion joint with EPDM O-ring seal.

2.05 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

3.01 INSTALLATION, GENERAL

A. Install pipe and specialties in accordance with manufacturer's installation instructions.

3.02 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.
2. Cast Iron Soil 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 and maintain continuous pipe slope. For piping with rock trench bottoms, provide sand pipe bed 6" underneath and around sides of pipe, including fittings. After pressure testing is complete, install subbase. Refer to Section "General Plumbing Requirements" for bedding and subbase materials, excavation, trenching, backfill and compaction requirements.

3.03 PIPE APPLICATIONS - ABOVE GROUND, WITHIN BUILDING

A. Install hubless, cast-iron soil pipe and fittings 15” and smaller for storm pipe.

3.04 PIPE APPLICATIONS - BELOW GROUND, WITHIN BUILDING

A. Install hub-and-spigot, service weight, cast-iron, soil pipe and fittings with gasketed joints for 15 inch and smaller storm pipe.

B. Install hubless, cast-iron soil pipe and fittings 15” and smaller for storm pipe.

C. As a contractor’s option with Owner approval, Install PVC Type DWV Plastic pipe and fittings for 24 inch and smaller storm pipe.

3.05 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.

3.06 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. Underground Exterior Wall Penetrations: Seal pipe penetrations through underground exterior walls using sleeves and mechanical sleeve sealers. Refer to Division 22 Section “Basic Piping Material and Methods” for additional information.

I. 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.

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. 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.

L. 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.

M. 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.

N. 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.

O. Extend building drain to connect to service piping, of size and in location indicated for service entrance to building. Storm service piping is specified in a separate section of Division 2.

P. Install 1 inch thick extruded polystyrene over underground building drain piping not under building. Width of insulation shall extend minimum of 12" beyond each side of pipe. Install directly over, and center on pipe center line.

3.07 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.

C. Install hangers at the following intervals and provide rods of diameter as listed below:

Nom. Pipe Size In Inches	Steel Pipe Max. Span In Feet	Copper Tube Max. Span. In Feet	Min. Rod Dia. - Inches Steel or Cast Iron	Min. Rod Dia. – Inches Copper or PVC
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
8	19	16	7/8	3/4
10	22	18	7/8	3/4
12	23	19	7/8	3/4

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 all sizes of horizontal of PVC piping every four feet.
4. Support all sizes of vertical of PVC piping every floor, but not to exceed fifteen feet.
5. Support piping within 12” of each elbow or tee.

3.08 INSTALLATION OF PIPING SPECIALTIES

A. Provide PVC DWV expansion joints every 30’ on straight vertical PVC waste or sanitary stacks receiving hot water waste. Install expansion joint at middle travel for equal expansion and contraction travel. Provide riser clamps within 18” of each end of expansion joint. Install expansion joint per manufacturer’s installation instructions.

B. Install expansion joints on stacks or horizontal piping as indicated, and as required by the plumbing code.

C. 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.

D. Cleanout Covers: Install floor and wall cleanout covers for concealed piping, types as indicated.

E. Floor Cleanouts: Install in below floor building drain piping at minimum intervals of 50' for piping 6" and smaller and 75' for larger piping.
   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.

F. Exterior Cleanouts: Install exterior cleanouts embedded in a 18" x 18" x 8" block of concrete, flush with finished grade.

3.09 INSTALLATION OF AREA DRAINS

A. Install area drains in locations indicated.

B. Install area 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 area drain elevation to match. Where architectural documents do not indicate the requirements, set the area drain

elevation depressed below the finished slab elevation as listed below to provide proper slope to drain:

DEPRESSION IN INCHES	RADIUS OF AREA DRAINED - FEET
1/2	5
3/4	10
1	15
1-1/4	20
1-1/2	25

D. Provide P-traps for drains connected to combined sanitary and storm sewer.

E. Install area drains in 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 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.

3.11 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.

3.12 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.

3.13 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 22 14 00

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL REQUIREMENTS

1.01 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 10 Section "Service Wall Systems" for wall modules with built-in plumbing fixtures.
3. Division 22 Section "General Duty Valves for Plumbing Piping" for valves used as supply stops.

1.02 DEFINITIONS

A. Accessible: Describes a plumbing fixture, building, facility, or portion thereof that can be approached, entered, and used by physically handicapped people.

Examples of accessory below are toilet seats, grab bars, and soap dishes.

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.

1.03 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
4. Shower valves and heads

1.04 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.

1.05 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. Faucet Cartridges and O-rings: Furnish quantity of identical units not less than 5 percent of amount of each installed.

D. Flushometer Repair Kits: Furnish quantity of identical units not less than 10 percent of amount of each flushometer installed.

E. Provide individual metal boxes or a hinged-top wood or metal box having separate compartments for each type and size of above extra materials.

F. 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

2.01 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. Fiat Products.
    c. Gerber Plumbing Fixture Corp.
    d. Kohler Co.
    e. PROFLO
    f. Sloan Valve Co.
    g. TOTO KIKI USA, Inc.
    h. Zurn Plumbing Products Group
2. Lavatories:
    a. American Standard, Inc.
    b. Fiat Products.
    c. Gerber Plumbing Fixture Corp.
    d. Kohler Co.
    e. PROFLO
    f. Sloan Valve Co.
    g. TOTO KIKI USA, Inc.
    h. Zurn Plumbing Products Group
3. Sinks:
    a. American Standard, Inc.
    b. Elkay Manufacturing Co.
    c. Just Manufacturing Co.
    d. PROFLO
4. Outlet Boxes:
    a. Guy Gray Manufacturing Co., Inc.
    b. Symmons Industries, Inc.
    c. Oatey Co.
5. Emergency Equipment:
    a. Bradley Corp.
    b. Chicago Faucet Co.
    c. ENCON Safety Products
    d. Guardian Equipment.
    e. Haws Drinking Faucet Co.

f. Speakman Co.
g. Stingray Systems
h. Water Saver Faucet Co.

6. Toilet Seats:
   a. Bemis Mfg. Co.
   b. Beneke Div.; Sanderson Plumbing Products, Inc.
   c. Church Seat Co.
   d. Kohler Co.
   e. Olsonite Corp.
   f. Sperzel Industries, Inc.
7. Flushometers – Piston Type:
   a. American Standard, Inc
   b. Kohler Co.
   c. Sloan Valve Co.
   d. Zurn Industries, Inc.; Flush Valve Operations.
8. Commercial/Industrial Cast-Brass Faucets:
   a. American Standard, Inc.
   b. Chicago Faucet Co.
   c. Delta-Commercial
   d. Speakman Co.
   e. T & S Brass and Bronze Works, Inc.
   f. Zurn Industries, LTD. “Aqua Spec”
9. Stop Valves & Supplies:
   a. Brass Craft Subsidiary; Masco Co.
   b. Chicago Faucet Co.
   c. Engineered Brass Company
   d. Kohler Co.
   e. McGuire Manufacturing Co., Inc.
   f. PROFLO
   g. T & S Brass and Bronze Works, Inc.
   h. Watts Brass and Tubular
   i. Zurn Industries
10. 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
11. 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.

12. Disposers:
a. General Electric Co.
b. Hotpoint; General Electric Co.
c. In-Sink-Erator Div.; Emerson Electric Co.
d. KitchenAid, Inc.
e. Thermador/Waste King; A Masco Co.

2.02 PLUMBING FIXTURES, GENERAL

A. Provide plumbing fixtures and trim, fittings, other components, and supports as specified on the drawings and below:

2.03 FAUCETS

A. Faucets General: As described on the drawings.
1. Electronic faucets shall be of the same manufacturer as the water closet and urinal flush valves.

2.04 STOP VALVES & SUPPLIES

A. Supplies General: As described on the drawings.
1. Exposed piping and parts shall be polished chrome plated.

2.05 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. Escutcheons: Wall flange with set screw.

C. Escutcheons: Polished chrome-plated, sheet steel wall flange with friction clips.

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.

2.06 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. Flush valves installed within wall construction may be without chrome plate finish.

2.07 TOILET SEATS

A. General: As described on the drawings.

2.08 DISPOSERS

A. Disposers: As specified on the drawings.

2.09 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.

2.10 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

3.01 INSTALLATION, GENERAL

A. Install fixtures, trim and supports in accordance with manufacturer’s installation instructions.

3.02 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 and drinking fountains.
   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 drinking fountains and 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. Floor-mounted lavatories required to be secured to wall.
   b. Floor-mounted sinks required to be secured to wall.
   c. Recessed, box-mounted electric water coolers.
   d. Wall mounted and mop sink faucets.

3.03 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 floor-mounted, floor-outlet water closets with closet flanges and gasket seals.

C. Install floor-mounted, back-outlet water closets with fittings and gasket seals.

D. Install wall-hanging, back-outlet water closets with support manufacturer's tiling frame or setting gauge.

E. Install wall-hanging, back-outlet urinals with gasket seals.

F. 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.

G. Fasten floor-mounted fixtures and special fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.

H. Fasten wall-mounted fittings to reinforcement built into walls.

I. Fasten counter-mounting-type plumbing fixtures to casework.

J. Secure supplies behind wall or within wall pipe space, providing rigid installation.

K. Set shower floors in leveling bed of cement grout.

L. Install stop valve in an accessible location in each water supply to each fixture.

M. Install trap on fixture outlet except for fixtures having integral trap.

N. 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.

O. 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.

P. 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.

3.04 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.

3.05 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.

3.06 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."

3.07 FIXTURE SCHEDULE

A. Provide plumbing fixtures as specified on the drawings.

B. Install rough-in for plumbing fixtures as scheduled on the drawings.

3.08 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
Lavatory or Sink	
Standard Height	31" floor to rim
ADA Accessible	34" floor to rim
Water Closet	
Standard	15" floor to rim
ADA Accessible	17” to 19" floor to top of seat
Water Cooler or Drinking Fountain	
Standard Height	41" floor to spout
ADA Accessible	36" floor to spout
Clinic Service Sinks	30” floor to rim
Surgeon’s Scrub-up Sinks	35” floor to front rim
Ice Maker Outlet Boxes	24” floor to center of box
Washing Machine Outlet Boxes	42" floor to rim
Janitor’s Sink Faucet Fittings	42” floor to centerline

END OF SECTION 22 40 00

SECTION 22 61 00
GAS AND VACUUM SYSTEMS FOR HEALTH CARE FACILITIES

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes oxygen, medical air, medical vacuum, nitrous oxide, nitrogen, carbon dioxide, and waste anesthetic gas disposal (WAGD) systems, including tubing, piping, fittings, equipment, and related accessories. Note that waste anesthetic gas disposal system (WAGD) is indicated as evacuation (EV) on the drawings.

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 7 Section "Joint Sealers" for materials and methods for sealing pipe penetrations through basement and foundation walls and fire and smoke barriers.
3. Division 11 Section "Equipment" for ceiling-mounted service columns, headwall units, and modular patient services units with medical gas outlets.
4. Division 22 Section “Coordination” for basic requirements for electrical components that are an integral part of packaged system components.
5. Division 22 Section "Identification, for Plumbing Piping and Equipment" for labeling and identification of gas and vacuum 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 strainers, flexible connectors, unions, flanges and flange kits, and mechanical sleeve seals.
8. Division 22 Section "Hangers and Supports for Plumbing Piping" for materials and methods for hanging and supporting gas and vacuum piping.

1.02 DEFINITIONS

A. Medical Gas System: The complete system to convey medical gases for direct patient application from central supply systems, including bulk tanks, manifolds, and medical air compressors, with pressure and operating controls, alarm warning systems, related components, and piping networks extending to station outlets at patient use points.

B. Medical Vacuum System: The complete system of central-vacuum-producing equipment with pressure and operating controls, shut-off valves, alarm-warning systems, gauges, and a network of piping extending to and terminating with suitable station inlets at locations where patient suction may be required.

C. Unless otherwise indicated herein, for the purposes of this Section, the term “medical gas system” shall include “medical vacuum system” also.

1.03 SUBMITTALS

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

1. Product data for the following products:
   a. Valves
   b. Medical gas system accessories
   c. Medical gas alarm system
2. Wiring diagrams for medical gas alarm systems, including ladder-type 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.

3. Inspection and test reports specified in “Field Quality Control” in this Section.
4. Certificates of inspections and tests from independent testing agency specified in “Field Quality Control” and ”Project Closeout Documents” in this Section.
5. Certificates indicating that medical gas tubing, fittings, valves, and other pipeline components are cleaned for oxygen service and are marked and sealed per NFPA 99.
6. Maintenance data for inclusion in Operating and Maintenance Manuals.
7. Brazers' qualification certificates, certifying that brazers meet the quality requirements specified under "Medical Gas and Vacuum System Brazers” and “Medical Gas and Vacuum System Installers" below.
8. Brazer brazing specifications indicating the proper procedure for the individual brazers to follow.
9. Verifier and Certifier certificates, certifying that verifiers and certifiers meet the quality requirements as specified under “Medical Gas System Inspector/Verifier” below.

1.04 QUALITY ASSURANCE

A. Installation of the medical gas systems shall comply with the following:
   1. 2018 edition of NFPA 99 ”Health Care Facilities Code”
   2. 2018 Uniform Plumbing Code
   3. American Society of Sanitary Engineering (ASSE) Series 6000
   4. The Missouri (State) Department of Health
   5. City of Lee’s Summit
   6. Owner’s Insurance Underwriter
   7. Authority Having Jurisdiction (AHJ)
   8. Applicable editions of Compressed Gas Association (CGA) standards:
      a. G-4.1 “Cleaning Equipment for Oxygen Service”
      b. G-4.3 “Commodity Specification for Oxygen”
      c. RC-7 “Compressed Air for Human Respiration”
      d. C-7.1 “American National Standard Commodity Specification for Air”

B. Electrical wiring of equipment and alarm systems shall comply with the 2017 edition of NFPA 70 “National Electrical Code.”

C. Equipment shall comply with UL 544 “Standard for Medical and Dental Equipment” and installation shall comply with local, state, and federal codes.

D. Equipment shall be listed and labeled by the Nationally Recognized Testing Laboratory. The terms “Listed” and “Labeled” shall be as defined in the “National Electrical Code,” Article 100.

E. Pipe joint make-up shall comply with ANSI/AWS A5.8, “Specifications for Brazing Filler Metal.”

F. Provide compatible accessories, tube, fittings, and valves for each system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store large medical gas accessories on factory-installed shipping skids, tubing with sealing plugs in ends or with end protection, and small accessories in factory-fabricated fiberboard containers.
   1. Store precleaned and sealed medical gas tube, fittings, valves, and accessories with sealing plugs and sealing packaging intact.
   2. Label medical gas tube, fittings, valves, and accessories that have not been precleaned, and that have been precleaned but have seal or packaging that is not intact, with temporary labels indicating that cleaning is required before installation.
   3. Material that has become contaminated and is no longer suitable for oxygen service shall not be installed.

4. Provide a separate designated storage area for all medical gas equipment, piping, outlets, etc. The designated storage area shall be protected, dry, have no construction debris or traffic, and shall be utilized only for the storage of medical clean piping and equipment; shall not be utilized to store any non-medical gas and vacuum piping or equipment. The designated separate storage area shall be labeled as such to prevent non-medical gas and vacuum piping and equipment from being accidently stored there and potentially being mistaken for medical gas piping and equipment.

1.06 PRE-CONSTRUCTION COORDINATION MEETING

A. Before medical gas piping and equipment installations begin, the General Contractor shall organize a Pre-Construction Meeting for the purposes of reviewing stockpiled medical gas piping and equipment, storage locations, installer and brazer certifications, certifications of verifiers and inspectors, and to review the verification and inspection procedures required for the project.

B. The pre-construction meeting shall be held at the project site, at a date and time convenient to the Owner. The meeting invitation shall include at a minimum the Owner (or his/her representative), the General Contractor, installing medical gas contractor, architect, engineer, verifier, inspector, and local authority having jurisdiction All invitees shall be given minimum 48-hour notice of meeting time and date. If invitees can not physically be on site to attend the meeting a conference call number shall be set up to allow for virtual participation.

1.07 PRE-CONSTRUCTION VERIFIER STANDING PRESSURE AND PARTICULATE TEST FOR EXISTING FACILITY

A. Before medical gas piping and equipment installations begin, the medical gas verifier shall perform a standing pressure and vacuum test to document the performance of the existing medical gas system. These results shall be utilized as a baseline when the final standing pressure and vacuum tests occur.

B. Before medical gas piping and equipment installations begin, the medical gas verifier shall perform a particulate and purity test to document the performance of the existing medical gas system. These results shall be utilized as a baseline when the final particulate and purity tests occur.

1.08 PRE-CONSTRUCTION CONNECTION TEST FOR EXISTING FACILITY

A. Before medical gas piping and equipment installations begin, the medical gas installer shall perform shut-off of the affected area valve, wait a minimum of 15 minutes, and the facility management shall check what alarms are activated by this action before cutting into any pipe. Take all steps necessary to make sure that the renovated piping on the plans matches field conditions.

1.09 PROPER ABANDONEMENT

A. Do not abandon any medical gas piping/equipment in place.

1.10 MEDICAL GAS SYSTEMS INSPECTOR/VERIFIER

A. The Medical Gas Systems Inspector/Verifier shall be contracted through the Construction Manager or Owner. The inspector/verifier shall not be hired or contracted by the medical gas installer.

B. Verification is required when a medical gas system is breached, pipeline intrusion, or component replacement.

C. The renovated portion of the system shall meet all the requirements of the adopted NFPA 99 version listed above.

D. The Medical Gas Systems Inspector/Verifier shall be trained and certified in accordance with ASSE Standard 6020, “Professional Qualifications Standard for Medical Gas Systems Inspectors” and ASSE Standard 6030, “Professional Qualifications Standard for Medical Gas Systems Verifiers.” Inspector/Verifiers shall have a minimum of two (2) years of documented practical experience in the inspection/verification of medical gas pipe line systems.

E. Medical Vacuum System Inspector/Verifier Certification to Standard 6020 and 6030 shall be through a recognized third party certification agency. Certification shall include the successful completion of a minimum 32-hour training course including a written and a practical examination covering all facets of ASSE Standard 6030, 6020, NFPA 99, and NFPA 55.

F. The Inspector/Verifier shall possess a current certificate of insurance, in the name of the individual or employing verification company, for general liability, completed operations, and as applicable, products liability insurance. The Inspector/Verifier shall provide the Owner and Engineer with a copy of insurance certificate.

G. Inspector/Verifiers shall complete report forms that include at a minimum the following items: date of test, medical gas verifier/installer identification, repairs and service performed, equipment warning systems, master, area and local alarm systems, other items as required by AHJ, pressure regulating valves, pressure relief valves, retest information, shut-off valves (source, main, riser, zone, service, etc.), source equipment, station outlets and inlets, and visual observation of physical conditions. Refer to ASSE Series 6000 Appendices B, C, and D for required checklist information.

H. Testing shall be conducted and test reports shall be submitted to the Engineer and Owner for approval.**MEDICAL GAS SYSTEM INSTALLERS**

A. All medical gas system installers shall be trained and certified in accordance with ASSE Standard 6010, “Professional Qualifications Standard for Medical Gas Systems Installers.” Installers shall have a minimum of four (4) years of documented practical experience in the installation of piping systems.

B. The medical gas systems installers shall be trained and certified to Standard 6010 through a recognized third party certification agency. Certification shall include the successful completion of a minimum 32-hour training course including a written and a practical examination covering all facets of ASSE Standard 6010, NFPA 99, and NFPA 55.

C. Furnish to the Engineer and Owner photocopies of third party ASSE Standard 6010 certification for each and every installer. Certifications shall include installers name, expiration date, certification number, and name of certifying agency. These certifications must be provided before beginning work. A simple list of installers' names shall not be considered acceptable.

D. Installers shall notify an inspector certified in accordance with ASSE Standard 6020 before any and all tests are performed so the results may be witnessed and recorded.

E. Installers shall record performance test results on a form similar to ASSE Series 6000 Appendix I, “Medical Gas System Installer Performance Testing Record”. Provide Engineer and Owner with copies of all test reports.

F. All supervisors, crew chiefs, etc. engaged in overseeing and/or directing medical gas systems installation or modification shall also be required to meet these standards.

1.12 MEDICAL GAS SYSTEM BRAZERS

A. The installation of medical gas systems shall be made by qualified, competent brazers who are experienced in making such installations. Brazing shall be performed only by brazers qualified under NFPA 99.

B. Prior to any installation work, furnish to the Engineer and Owner photocopies of the qualification of individual brazers that is required under NFPA 99..

C. Prior to any installation work, furnish to the Engineer and Owner photocopies of the Record of Continuity of Brazer Qualifications for each brazer.

D. Brazing procedures and brazer performance for the installation of medical gas piping shall be qualified in accordance with either Section IX, “Welding and Brazing Qualifications,” of the ASME Boiler and Pressure Vessel Code or AWS B2.2, Standard for Brazing Procedure and Performance Qualifications, both as modified by NFPA 99.

1.13 PROJECT SCHEDULING

A. Any construction work which will require the facility's medical gas systems to be shut down shall require a minimum of 7 day advance notification to the Owner. All shutdown procedures shall comply with ASSE Series 6000 and facility requirements.

B. Schedule work to ensure all medical gas piping, equipment, outlets, etc. are installed, and that all medical gas systems are tested and certified prior to substantial completion.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. The manufacturer's products listed herein and provided shall be compatible with the facility's existing medical gas equipment, components, and devices, where applicable, and shall be approved by the Owner.

B. One manufacturer, unless otherwise specified herein or on the Drawings, shall supply the medical gas equipment, components, and devices as listed below. Refer to the Drawings for model numbers.

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

1. Systems Accessories:
    a. Allied Healthcare Products, Chemetron Div.
    b. Amico Corp.
    c. Beacon Medaes
    d. Ohio Medical Corp., Squire-Cogswell Div.
    e. Patton's Medical
2. Zone Valve Boxes:
    a. Allied Healthcare Products, Chemetron Div.
    b. Amico Corp.
    c. Beacon Medaes
    d. Ohio Medical Corp., Squire-Cogswell Div.
    e. Patton's Medical
3. Alarm Systems:
    a. Amico Corp.
    b. Beacon Medaes
    c. Ohio Medical Corp., Squire-Cogswell Div.
    d. Patton's Medical
4. Wall/Ceiling Outlets:
    a. Allied Healthcare Products, Chemetron Div.
    b. Amico Corp.
    c. Beacon Medaes
    d. Ohio Medical Corp., Squire-Cogswell Div.
5. Medical Gas Flowmeters
    a. Beacon Medaes

2.02 COMPONENTS, GENERAL

A. Copper tube, fittings, valves, and other piping components shall be precleaned for oxygen service by the manufacturer in accordance with CGA Pamphlet G-4.1 prior to installation and

shall be delivered plugged, capped, or sealed and permanently labeled or marked per NFPA 99.

B. On-site cleaning of the interior surfaces of tubes, valves, fittings, and other piping components prior to brazing shall be limited. Refer to Part 3, Article “Preparation.”

C. Copper tube and fitting sizes are nominal inside diameter.

2.03 TUBE MATERIALS

A. Refer to Part 3, Article “Tube Applications”, for identification of systems where the materials listed below are used.

B. Precleaned and Sealed Copper Tube: ASTM B819, Type K or L, hard drawn temper, seamless medical gas tubing marked “OXY,” “MED,” “OXY/MED,” “OXY/ACR,” or “ACR/MED.”

2.04 TUBE FITTINGS

A. Wrought Copper Solder-Joint Fittings: ANSI B16.22, solder-joint, pressure type designed for brazed joints.

B. Bronze Tube Flanges: ANSI B16.24, Class 300, designed for brazed tubing connection.

C. Flexible Connectors shall be provided with medical air compressor and medical vacuum pump as a component of the packaged units.

D. Threaded joints and connections shall be permissible where indicated in NFPA 99.

2.05 TUBE AND FITTING JOINING MATERIALS

A. Screwed Joint Pipe Tape: Polytetrafluoroethylene (PTFE) plastic.

B. Gasket Material: ANSI B16.21, nonmetallic, flat, asbestos-free, and suitable for oxygen use.

C. Brazing Filler Metals: ANSI/AWS A5.8, BAg-5, with a cadmium content of zero, with approved flux suitable for oxygen service.

D. Brazing Filler Metals: ANSI/AWS A5.8, BCuP-5, with a minimum silver content of 15%. Flux is prohibited.

2.06 VALVES

A. Shut-off Valves 4 Inches and Smaller: Bronze-body, three-piece, full-size port, bolted-ball type, with chrome-plated brass ball, with Teflon (TFE) seats, buna or Teflon stem seals, blow-out proof stem, Type K copper tube extensions suitable for brazing and with protective end covers, quarter-turn operation between open and closed positions, designed for working pressures up to 600 psi or vacuum service up to 29 inch Hg, and factory-cleaned for oxygen service. Valves shall be of the locking type where indicated on the Drawings.

B. Check Valves 3 Inches and Smaller: Bronze-body, straight-through pattern, spring-loaded plunger, designed for working pressures up to 400 psi, and factory-cleaned for oxygen service.

C. Safety Valves: Bronze-body with settings to match system requirements and factory-cleaned for oxygen service.

1. Pressure Relief Valves: Bronze construction and designed for oxygen service.
2. Vacuum Relief Valves: Equipment manufacturer’s option.

D. Automatic Drain Valves: Corrosion-resistant metal body and internal parts, 200 psig minimum rated working pressure, and capable of automatic discharge of collected condensate.

2.07 ZONE VALVE BOXES

A. General: Valve rough-in box shall be constructed of minimum 18-gauge steel or extruded aluminum for recessed mounting, with holes for medical gas tubing and anchors. Provide for single or multiple valve installation and in sizes as indicated on the Drawings to permit manual operation of valves.

B. Shut-off Valve(s): Same as described in Part 2, Article “Valves” and shall be provided with color-coded medical gas identification labels and pressure gauge ports in the extension downstream of the valve (upstream for vacuum). The valve body and pipe stubs shall be chrome-plated to beyond the valve rough-in box.

C. Interior Finish: Factory-applied white enamel.

D. Finishing Window Frame: Anodized extruded aluminum sections with mitered welded corners and provided with clear or tinted transparent removable plastic window with pull ring to remove in an emergency and factory or field-installed labeling (including space for rooms served) in accordance with NFPA 99. The window shall be labeled “Caution: Medical Gas Control Valve – Close Only in Emergency.”

E. Pressure/Vacuum Gauge(s): Factory-installed with 2 inch dial in accordance with ASME B40.1, Grade B. Gauge range shall be such that the normal operating pressure is within the middle third of the total range.

2.08 ALARM SYSTEMS

A. General: Medical gas alarm systems shall consist of compatible alarm panels, remote sensing-devices, and other related components where indicated and as required by NFPA 99. Power and control wiring are specified in Division 26.

B. Electrical Components: Designed for continuous service and to operate on power supplied from 120V power source to alarm panels and have connections for 24V or 12V a.c. low-voltage wiring to remote sensing devices. Provide step-down transformers where required.

C. Actuating Devices: Pressure and vacuum switches or pressure transducer sensors, mounted locally or remotely as indicated on the Drawings, shall provide for continuous line monitoring with electrical connections for each medical gas alarm system. Switches shall be housed in a NEMA 4 watertight enclosure and shall be factory-cleaned for oxygen service.

1. High-low pressure switches for oxygen, medical air, nitrous oxide, and carbon dioxide systems: Up to 80 psig operating range.
2. Low vacuum switches for medical vacuum and WAGD systems: Up to 30 inch Hg. Range.
3. Gauges: Provide main line gauges in medical gas/vacuum piping mains adjacent to main line pressure/vacuum switches.

D. Alarm Panels: Recessed, closed-circuit, self-monitoring type with LED digital readouts, solid state with plug-in circuit boards, and factory-wired with audible and color-coded visible signals to indicate functions as specified herein and required by NFPA 99. Panels shall be properly labeled to indicate rooms or areas served by each medical gas. Provide alarm panels with interface capabilities to automated building management system where indicated.

E. Enclosures: Constructed of minimum 18-gauge steel or aluminum with mounting brackets and knockouts for electrical tubing connections.

F. Area Alarm Panels: Provide area alarm panels with 1/4” Type K copper monitoring extensions for local sensors or dry contacts for remote sensors where indicated. Area alarm panels shall alarm when any of the following conditions occur:

1. Oxygen: Local line pressure drops to 40 psig and below or rises to 60 psig and above.
2. Medical Air: Local line pressure drops to 40 psig and below or rises to 60 psig and above.
3. Medical Vacuum: Local line vacuum drops to 12 inches Hg. and below.

2.09 MEDICAL GAS SYSTEM ACCESSORIES

A. General: Provide the following medical gas system accessories by the same manufacturer.

B. Quick-Connect Recessed Wall Outlets: Include brass valve and body block with seals in roughing-in and finishing assemblies, color coded front plate, one piece chrome fascia plate with medical gas identification, 1/4-inch inside diameter Type K copper tube brazed to valve, and pressure outlets equipped with a primary and secondary check valve to prevent gas flow when the primary valve is removed. Outlet bodies shall be indexed to prevent interchange between services, constructed to permit one-handed connection and removal of equipment with positive locking ring which retains equipment stem in valve during use. Outlets shall be of modular design and include a gas specific mounting plate to permit ganging of multiple outlets.

C. DISS (Diameter Index Safety System) Type Recessed Ceiling Outlets: Include brass valve and body block with seals in roughing-in and finishing assemblies, color coded front plate, one piece

chrome fascia plate with medical gas identification, 1/4-inch inside diameter Type K copper tube brazed to valve, and pressure outlets equipped with a primary and secondary check valve to prevent gas flow when the primary valve is removed. Outlet bodies shall be indexed to prevent interchange between services. Outlets shall be of modular design and include a gas specific mounting plate to permit ganging of multiple outlets. Outlets shall be provided with hose assemblies with 60" long, FDA approved medical grade thermoplastic conductive reinforced rubber hose with color-coding complying with CGA C-9 standard, DISS female inlets and quick-connect outlets, and hose retractor with stainless steel housing and 48" heavy duty cable mounted to outlet cover plate.

D. Vacuum Bottle Slide Brackets: Bottle slide and mounting assembly matching pattern of vacuum outlet. Provide 1 slide bracket for each wall-mounted vacuum inlet, except where no slide bracket requirement is indicated.

E. Power and Medical Gas Columns: Provided under another division of work. Make final medical gas piping connections to columns above ceiling, unless otherwise indicated.

2.10 MEDICAL GAS FLOWMETERS

A. Flowmeter operated by thermal conductivity to meter direct mass flow. Includes temperature and pressure compensation, precise measurement with standard turndown of 100 to 1 and maximum resolution of 1000 to 1. No moving parts.

B. Stainless flow condition tube for laminar flow. Enclosed in rugged cast aluminum housing suitable for indoor or outdoor applications.

C. Display is high contrast OLED with photocell activated screen saver to extend display life. Displays provided include:

1. Flow rate in CFM
2. Bar graph indicator
3. Total flow
4. Temperature
5. Calibration mW

D. Flowmeter and flow conditioning tubes are cleaned and bagged for oxygen service. Flowmeter shall comply with NFPA 99 2018.

PART 3 - EXECUTION

1.

3.02 PREPARATION

A. On-site cleaning of the interior surfaces of tubes, valves, fittings, and other piping components shall be limited to recleaning surfaces in the immediate vicinity of the joints that have become contaminated prior to brazing.

B. When precleaned medical gas piping components must be recleaned due to contamination, perform the following procedures:

1. Clean interior surfaces at the joints of piping components free of oil, grease, and other readily oxidizable materials as required for oxygen service.
2. Wash surfaces of components at the joints in a clean, hot water/alkaline solution of sodium carbonate or trisodium phosphate in proportion of one pound of chemical to three gallons of potable water.
    a. Thoroughly scrub to ensure complete cleaning.
    b. Rinse with clean, hot potable water after washing to remove cleaning solution.

3.03 TUBE APPLICATIONS

A. Install Type L, hard drawn copper tube with wrought copper fittings and brazed joints for sizes 1/2 inch and larger, above ground, within building.

B. Connections to pressure gauges and alarm switches and monitoring line runouts to area alarm panels shall be 1/4 inch in size, unless indicated otherwise, of same material as main and branch tubing.

3.04 PIPING INSTALLATION, GENERAL

A. Install eccentric reducers where pipe is reduced in size in the direction of flow, with bottoms of both pipes and reducer flush.

B. Install horizontal piping as high as possible. Install vertical piping tight to columns or walls. Allow sufficient space above removable ceiling panels to allow for panel removal.

C. Install piping specialties in accordance with Division 22 Section "Basic Piping Materials and Methods."

D. Install thermometers and pressure gauges where indicated on the drawings. Pressure gauge and thermometers are specified in Division 22 Section "Meters and Gauges for Plumbing Piping."

E. Piping exposed to physical damage shall be adequately protected.

F. All piping shall be pitched so as to drain to accessible locations. All branch takeoffs or runouts shall be taken off above the centerline of the main or branch pipe and rise vertically or at an angle of not less than 45 degrees from the vertical.

G. 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.

H. 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.

I. Joints at Valve Assemblies: Provide bronze 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”.

3.05 TUBING JOINT CONSTRUCTION

A. Particular care shall be exercised in the storage and handling of tube and fittings which shall be capped or plugged to prevent contamination before final assembly. Tools used in cutting or reaming shall be kept free from oil or grease. Contaminated material that is no longer suitable for oxygen service shall not be installed, but shall be replaced with new.

B. Bends: Changes in direction requiring turns or offsets shall be made by brazed wrought copper fittings.

C. Unions shall not be permitted in the medical gas piping distribution system.

D. 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. Leave first thread clean if possible.

E. Openings in the piping system shall be kept capped or plugged during and after installation to prevent loss of purge gas while brazing and to prevent debris or other contaminants from entering the system.

F. Brazing For Copper Tube and Fittings:

1. Braze joints in accordance with NFPA 99 with BCuP-5 brazing filler metal.
2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making brazed joints. Wipe tube and fittings clean. Prevent the entry of matter into the tube. If matter enters the tube, replace the tube or clean the tube in the field per NFPA 99. Use of flux is prohibited.

3. Continuously purge each with oil-free dry nitrogen during brazing procedures to prevent oxidation and scale formation on the inside surface of the copper tube and joints. The nitrogen flow shall be maintained until the joint is cool to the touch.
4. Clean the outside of the tube and fittings after assembly with hot water.

G. Brazing For Dissimilar Metals:

1. Braze joints in accordance with NFPA 99 with BAg-5 brazing filler metal and approved flux suitable for oxygen service.
2. Thoroughly clean pipe and tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making brazed joints. Wipe tube and fittings clean. Prevent the entry of matter into the tube. If matter enters the tube, replace the tube or clean the tube in the field per NFPA 99.
3. Continuously purge each with oil-free dry nitrogen during brazing procedures to prevent oxidation and scale formation on the inside surface of the copper tube and joints. The nitrogen flow shall be maintained until the joint is cool to the touch.
4. Clean the outside of the tube and fittings after assembly with hot water.

3.06 INSTALLATION OF VALVES

A. Valve Applications:

1. Provide ball valves specified herein for shutoff duties at the medical gas source, main line, base-of-risers, and where indicated on the Drawings.
2. Provide check valves specified herein at cylinder manifold and bulk tank systems in the primary supply main, upstream of the point of intersection with the secondary or reserve supply main as required by NFPA 99, at emergency oxygen inlet, and where indicated on the Drawings.
3. Provide a pressure relief valve set at 50 percent above normal line pressure operation downstream of shut-off or check valve required at each pressure regulator.
4. Provide vacuum relief valves at medical vacuum pumps where indicated on the Drawings and required by NFPA 99.
5. Provide automatic drain valves at medical air compressors where indicated on the Drawings and required by NFPA 99.

B. Install zone valves in valve box anchored to structure. Install valves at angle that prevents closure of cover when valve is in closed position. A single box may be used for multiple valves when valves serve same area or same function.

3.07 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. Copper plated adjustable band swivel ring type hangers, MSS SP-69 Type 10, for copper tube for individual horizontal runs.
2. Copper plated piping riser clamps, MSS SP-69 Type 8, for individual vertical runs.
3. 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 and chases, or for supporting copper tubing above the floor with pipe supports attached to the floor with anchor bolts. Secure clamp to the copper tube.
4. Support copper tube in chases and walls at wall outlets with plastic or copper brackets secured to structure and plastic coated U-bolts sized to bear on the pipe.
5. 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 secured to the bare pipe and provide plastic galvanic isolators for bare copper tube.

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.
1/4	5	3/8
3/8	6	3/8
1/2	6	3/8
3/4	6	3/8
1	6	3/8
1-1/4	6	3/8
1-1/2	10	3/8
2	10	3/8
2-1/2	10	3/8
3	10	3/8
4	10	3/8
5	10	1/2
6	10	1/2

1. Support vertical copper tube at each floor and at intervals not to exceed 15 feet.

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

E. 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".

3.08 CONNECTIONS

A. General: Install valves that are same size as the piping connecting the equipment.

B. Where medical gas piping to source equipment connections are dissimilar metals, install dielectric unions for joints 2" and smaller and install dielectric flanges for joints 2-1/2" and larger. Dielectric unions and flanges are specified in Division 22 Section "Basic Piping Materials and Methods." Provide unions or flanges downstream of shutoff valves. Provide unions or flanges upstream of shutoff valves for vacuum.

1. Install flexible pipe (tubing) connectors on air tubing connections to medical air compressors, vacuum tubing connections to medical vacuum pumps, and where indicated. Flexible tube connectors are specified in Division 22 Section "Basic Piping Material and Methods".
2. Install thermometers on medical air compressor discharge tubing, medical air receiver tanks, medical vacuum receiver tanks, and where indicated. Thermometers are specified in Division 22 Section "Meters and Gauges for Plumbing Piping."
3. Install pressure gauges on medical air compressor discharge tubing, air receiver tanks, vacuum receiver tanks, and where indicated. Pressure gauges are specified in Division 22 Section "Meters and Gauges for Plumbing Piping."

C. Electrical wiring and connections are specified in Division 26 section "Common Work Results for Electrical".

3.09 EQUIPMENT INSTALLATION:

A. General: Install medical air compressor and vacuum pump per the manufacturer's published recommendations. Install units plumb and level, firmly anchor to the locations indicated, and maintain manufacturer's clearances.

B. Supports: Install packaged units on a 4" high concrete housekeeping pad, 4" larger than the outside dimension of the base. Mount units on concrete inertia bases.

C. Electrical wiring: Install devices furnished by the manufacturer, but, not specified to be factory installed. Furnish a copy of wiring diagram submittal to the Electrical Contractor. Verify that electrical wiring installation is in accordance with the manufacturer's submittal requirements. Do not proceed with equipment start-up until wiring installation is acceptable to the equipment manufacturer's representative.

D. Equipment Connections: Provide connections to the medical air and vacuum systems as indicated and comply with the equipment manufacturer's instructions. Install valves that are same size as the piping connecting the equipment. Install tubing and piping adjacent to equipment to allow servicing and maintenance.

1. Air Compressor Air Intake: Comply with equipment manufacturer's sizing requirements and NFPA 99 clearance requirements.
2. Vacuum Pump Exhaust: Comply with equipment manufacturer's sizing requirements and NFPA 99 clearance requirements.

E. Testing and Start-up: The equipment manufacturer's representative shall conduct factory tests and inspect installation. The equipment manufacturer's representative shall provide to the architect documentation that the equipment installation meets factory installation requirements and that the equipment performance meets factory specifications.

3.10 ACCESSORIES INSTALLATION

A. Install accessories in accordance with NFPA 99 and manufacturer's printed installation instructions

3.11 ALARM SYSTEM INSTALLATION

A. General: Install alarm system components in accordance with NFPA 99 and manufacturer's printed installation instructions.

B. Install alarm panels in locations indicated.

C. Electrical wiring and connections are specified in Division 26 section "Common Work Results for Electrical".

D. Coordinate interlock of air compressor and vacuum pump high temperature alarms with building automation system. Alarm wiring and alarm interlock with the building automation system are specified in Division 23 Section "Direct-Digital Control for HVAC".

3.12 LABELING AND IDENTIFICATION

A. Install labeling on tubing, valves, valve box covers, and alarm panels in accordance with requirements of NFPA 99 (e.g. every 20 feet, per room, per each side of wall and per floor.). Refer to Division 22 Section "Identification for Plumbing Piping and Equipment" for piping within building, tubing, valves, gauges, alarms, and accessories.

B. Captions and Color Coding: Use the following or similar medical gas captions and color coding for accessories, when specified and where required by NFPA 99.

1. Oxygen: White letters on green background.
2. Medical Air: Black letters on yellow background.
3. Medical Vacuum: Black letters on white background.

C. Where supplementary color identification of piping is used, it shall be in accordance with the gases and colors indicated in CGA Pamphlet C-9, "Standard Color-Marking of Compressed Gas Cylinders Intended for Medical Use."

D. Label medical gas distribution systems operating at other than standard pressure with system operating pressure.

E. Medical gas valve tags shall meet NFPA 99 requirements.

3.13 FIELD QUALITY CONTROL

A. Installer Pre-Test: Perform odor test on all medical gas piping and outlet batches prior to installation to ensure that no objectionable odors exist.

B. Installer Testing: Prior to declaring the medical gas system ready for final verification and certification, follow the procedures for verification as indicated in NFPA 99 and ASSE 6010 and can confirm that the following standard has been met:
   1. System Clearing: Purge medical gas system tubing using oil-free dry air or nitrogen after installation of tubing but before installation of service outlet valves, alarms, and gauges.
   2. Pressure Test: Subject each section of each system to test pressure from 150 psig to 200 psig with oil-free dry air or nitrogen before attachment of system components, after installation of station outlets with test caps (when supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water.
   3. Cross Connection Test: Determine that each outlet is connected to the appropriate line by flowing gas through each system. Test one system at a time using nitrogen.
   4. Initial Piping Purge Test: High flow through assembled outlets.
   5. Standing Pressure Test: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at 20 percent above normal line pressure but not less than 66 psig. Subject vacuum system to 12 to 18 inches of mercury minimum vacuum in lieu of pressure test. Test shall be witnessed by AHJ or Designee.
   6. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
   7. Repair medical gas systems and replace components that fail tests specified.
   8. Provide to the engineer a completed copy of “Medical Gas System Installer Performance Testing Record” (or similar report) as found at the end of this specification section once all requirements of NFPA 99 and ASSE 6000 series have been met.

C. Inspector Performance Requirements: The inspector shall perform all the required duties as indicated in ASSE 6000 Series including but not limited to:
   1. Inspector’s log: Maintain a log that contains records of site observations and test results required for inspectors.
   2. Test and inspection reports: The inspector shall personally witness the various tests and record the results of the tests performed by the installer as require.
   3. The inspector shall verify that the following documents are on file at the jobsite: Building permit, shop drawings, manufacturer’s literature and data, manufacturer assembly test documentation for each manufacturer’s unit, copper tubing and fittings cleaned for oxygen service documentation, brazing alloy documentation, purge and test gas documentation, qualification of brazing procedure specification, brazer performance qualification record, and qualification of welding procedures and welders if used, medical gas system installer certifications to ASSE Standard 6010 for each medical gas system installer, Medical Gas Systems Verifier certification to ASSE Standard 6030, and bulk medical gas system installers certifications to ASSE Standard 6015.
   4. The medical gas systems inspector shall confirm the following: Use of proper piping materials and joining methods, proper handling and installation of materials including supports, brazed piping purged with nitrogen NF while being brazed and capped or plugged during the installation process, welding piping purged with shield gas while being welded and capped or plugged during the installation process, labeling and identification, installation of manifolds, installation of bulk medical gas supply sources, installation of medical compressed air source equipment, and installation of medical vacuum source equipment, installation of alarm panels.
   5. The medical gas systems inspector shall verify the test reports for the following: Visual inspection of brazed and welded joints, inspection of all welded test coupons, initial piping blow-down, initial pressure test, initial cross-connection test, standing pressure test, standing vacuum test, initial piping purge test.

6. The medical gas systems inspector shall obtain a copy of the final system verification report performed in accordance with ASSE 6000 Series.
7. The medical gas systems inspector report data shall include:
    a. Medical gas systems inspector identification
    b. Medical gas systems inspector signature
    c. Date of test

D. Verifier Testing: Once the Installer Checklist is complete, the following is the general list of items per ASSE 6000 Series that the Medical Gas Verifier is to certify, including but not limited to the following:
1. Prepare Test Equipment: All pressure/vacuum gauges, flow meters, adapters, medical gas analyzers, and other test equipment shall be medical gas clean, calibrater, and meet all other requirements of ASSE 6000 series.
2. Standing pressure and vacuum tests: Verify that the distribution piping for positive pressure and vacuum medical gases is still free from leaks since being leak tested by the installer.
3. Cross-connection Test (by individual pressurization or pressure differential: Verify that no cross-connections exist within any of the medical gas, instrument air, vacuum distribution and WAGD systems.
4. Shut-off valve test: Verify that all shut-off valves in a medical gas and vacuum system function properly and are properly labeled.
5. Master, area, and local alarm test: Verify that master, area, and local alarm systems function properly and are properly labeled.
6. Piping purge test: Purge particulate matter from all positive pressure pipelines after construction.
7. Piping particulate test: Verify the cleanliness of each positive –pressure medical gas piping system.
8. Piping Purity test: Verify that the pressurized patient medical gas distribution systems are not contaminated by excessive water vapor (pressure dew point), total hydrocarbons (as methane) and halogenated hydrocarbons.
9. Final tie-in test: Establish test procedures for verifying that where tie-ins are made to existing medical gas and medical support gas piping systems, the outlets downstream from the tie-in, in both the new and the existing piping are ready for acceptance by the AHJ or responsible facility authority.
10. Operational pressure test: Verify that the decreases in line pressure or vacuum are not excessive with prescribed flow rates at the outlets and inlets.
11. Medical gas concentration test: Verify that the proper concentration of system gas is present at each medical gas outlet after the test gas (nitrogen NF); is purged from the distribution piping. After thorough purging of all test gas, the required concentration of the specific system gases at each outlet shall per ASSE 6030 Table 1 (values as follows):
    a. Oxygen: equal to or greater than +99%
    b. Nitrous oxide: equal to or greater than +99%
    c. Nitrogen: equal to or greater than +99% nitrogen or equal to or less than 1% oxygen.
    d. Synthetic Medical Air USP 19.5% to 23.5% oxygen
    e. Compressed Medical Air USP: equal to or greater than 20.9% oxygen
    f. Other gases: Concentraton as specified by their labeling +/- 1%
    g. CSA:
        1) Oxygen: 99%
        2) Medical Air: 19-23%

3) Nitrous Oxide: 95%
4) Nitrogen 99%

12. Medical air purity test for compressor systems: Verify that the medical compressed air source equipment is installed in accordance with the requirements of NFPA 99.
13. Labeling of system components: Verify the presence and correctness of the labeling for components of the medical gas and vacuum distribution system (e.g. distribution piping, station outlets and inlets, shut-off valves, pressure gauges, alarm panels, etc.)
14. Medical gas supply source tests: Verify that medical gas supply manifolds changeover properly to a secondary and/or reserve supply and that proper alarms and indications are received in the master alarm systems.
15. Medical air compressor system tests: Verify the quality of medical air from systems utilizing on-site air compressors as the source.
16. Medical/surgical vacuum system tests: Verify that the medical vacuum source equipment is installed in accordance with the requirements of NFPA 99
17. Bulk medical gas supply system tests: Verify that the bulk medical gas supply system is communicating with the facility's master alarm system for medical gases and that the facility can monitor the bulk medical gas supply.

E. The medical gas system verifier shall provide their own nitrogen test gas. If the Verifier does not have their own nitrogen purge gas, the Verifier may, at their own expense, purchase nitrogen from the medical gas installer.

F. The General Contractorshall provide the engineer the results of tests.

G. Provide the Owner an operational and functioning medical gas system with all certifications, test reports, observation reports, etc. without qualifications.

3.14 COMMISSIONING

A. Provide the services of a factory-authorized service representative to inspect alarm system installation and to provide start-up service.

B. Operate and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment discovered by the service representative.

C. Checks before Start-up: Perform the following final checks before start-up:

1. Verify that specified tests of piping systems are complete.
2. Check that safety (pressure-relief) valves have correct setting that is greater than medical air compressor discharge pressure, but not greater than pressure rating of system components.

3.15 DEMONSTRATION

A. Provide the services of a factory-authorized service representative to demonstrate alarm system start-up and shut-down procedures, preventative maintenance and servicing procedures, and troubleshooting procedures. Review operating and maintenance information.

B. Provide 7-day written notice in advance of demonstration.

END OF SECTION 22 61 00

MEDICAL GAS SYSTEM
INSTALLER PERFORMANCE TESTING RECORD

Testing is done per the requirement of ASSE standard 6010 and NFPA 99. All installer testing shall be performed by certified medical gas installers. The test gas used shall be nitrogen. In Canada: the test gas shall be oi-free dry air or oil-free dry nitrogen.

FACILITY NAME: _____ AREA: _____
Project Manager:_____ Job Foreman:_____
Test Date: __/__/____ Start Time: __:__ AM/PM End Time: __:__ AM/PM

Medical Gas Installer:_____ Certification Number:_____
Medical Gas Brazer:_____ Certification Number:_____
O2 Analyzer: _____ Certification number:_____
Systems Certifications: _____

1. Initial Blow Down Test
    a. Intermittent flow of nitrogen NF through piping.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Oxygen				
Medical Air				
Nitrous Oxide				
Carbon Dioxide				
Nitrogen				
Instrument Air				
Medical/Surgical Vacuum				
WAGD				

2. Initial Pressure Test (Joints/Pipe Integrity)
    a. Pressure test of 1-½ times the working pressure, 1035 kPa (150 psig) minimum, nitrogen at 1655 kPa (240 psig) minimum using nitrogen.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Oxygen				
Medical Air				
Nitrous Oxide				
Carbon Dioxide				
Nitrogen				
Instrument Air				

3. Initial Pressure Test for Vacuum Systems
    a. Pressure test of 1035 kPa (150 psig) minimum using nitrogen.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Medical/Surgical Vacuum				
WAGD				

4. Cross-Connection Test (Initial)
    a. Determine that each outlet is connected to the appropriate line by flowing gas through each system. Test on system at a time using nitrogen.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Oxygen				
Medical Air				
Nitrous Oxide				
Carbon Dioxide				
Nitrogen				
Instrument Air				
Medical/Surgical Vacuum				
WAGD				

5. Initial Piping Purge Test
    a. High flow through assembled outlets.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Oxygen				
Medical Air				
Nitrous Oxide				
Carbon Dioxide				
Nitrogen				
Instrument Air				
Medical/Surgical Vacuum				
WAGD				

6. Standard Pressure Test for Positive Pressure Piping
    a. Twenty-four (24) hour standing pressure test at 20% above normal line pressure using nitrogen NF with outlets and other components assembled.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Oxygen				
Medical Air				
Nitrous Oxide				
Carbon Dioxide				
Nitrogen				
Instrument Air				

7. Standing Pressure Test for Vacuum Systems
    a. Twenty-four (24) hour standing vacuum test at 300 mm (12 inches) gauge HgV with inlets and other components assembled.

Medical Gas System	Date	Tested By	Pass/Fail	Test Accepted By
Medical/Surgical Vacuum				
WAGD				

SECTION 23 00 10
GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL REQUIREMENTS

1.01 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.

1.02 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 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.

1.03 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:

BOCA	Building Officials Code Administration
UBC	Uniform Building Code
UMC	Uniform Mechanical Code
UPC	Uniform Plumbing Code
IBC	International Building Code
IMC	International Mechanical Code
IPC	International Plumbing Code
IECC	International Energy Conservation 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
FGI	Guidelines for Design and Construction of Hospital and Healthcare Facilities
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.

1.04 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.

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: Bedding as used in this section refers to the compacted sand or pea gravel installed in the bottom of a trench to immediately support and cover a pipe or duct.
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. Building Fill: Building fill as used in this section refers to borrowed fill material of rock 1” and larger used to fill foundation excavations

1.05 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 his 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 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.

G. The mechanical contractor is responsible to the general contractor for the shop drawing layout of the following rooms and details. Prior to construction, contractor shall submit shop drawings of the following to Design Engineer for review.

1. Concrete pads and foundations.
2. Equipment room layouts with actual equipment, piping and duct.
3. Roof layouts.
4. Trench locations and sizes.
5. Dimensioned floor drain locations.
6. Congested areas (i.e. above ceilings adjacent to powerhouse or equipment rooms, etc.).

H.

1.06 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.

1.07 SUBMITTALS

A. Refer to Division 01 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 Divisionas noted in Table 1 at the end of this Section. Provide the number of submittals required by Division 01; 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 resubmittal if required. Transmit submittals as soon as possible after Notice to Proceed and before Mechanical 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. 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.

1.08 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF 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. Contact the Architect for Architect's written authorization. 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. In addition to payment, Architect's written authorization and Engineer's release agreement form must be received before electronic drawing files will be sent.

1.09 SUBSTITUTIONS

A. Refer to Division 01 and General Conditions for Substitutions and Hospital preferred vendors.

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

C. 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. Each such request shall include the name of the material or equipment for which substitution is being requested, and a complete description of the proposed substitution including drawings, cut sheets, performance and test data, and all other information necessary for an evaluation. Include a statement setting forth changes in other materials, equipment or other work that incorporation of the substitution would require. The burden of proof of the merit of the proposed substitution is upon the proposer. The Engineer's decision to approve or disapprove a substitution in a Bid is final.

D. 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.

E. 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 and record drawing requirements.

1.11 SPARE PARTS

A. Provide to the Owner the spare parts specified in the individual sections in Division 23 of this specification. Refer to Table 2 at the end of this Section for a list of specification sections in Division 23 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. 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.

B. Refer to Division 01 and General Conditions for Record Drawings

1.13 TRAINING

A. Provide training as indicated in each specific section. Schedule training with the Owner at least 7 days in advance. 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.

1.14 PAINTING

A. Paint the following work where exposed in equipment rooms and outside the conditioned building envelope refer to division 9 for additional instructions and rquirements:

1. uninsulated metal piping;
2. uninsulated plastic piping;
3. pipe hangers and supports;
4. tanks that do not have factory-applied final finishes;
5. duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material;
6. equipment, stands, supports, intake bonnets, flutes, and all factory-primed items to receive final paint that are exposed to view in equipment rooms, on the ro of or outside the building.
7. Exposed galvanized sheetmetal installed outside of the conditioned building envelope, including in mechanical spaces that are heated only, is not required to be painted but shall be coated to prevent rust and corrosion.

B. Paint the following work where exposed in occupied spaces:

1. uninsulated metal piping;
2. uninsulated plastic piping;
3. pipe hangers and supports;
4. duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material;
5. other items as directed by Architect;
6. equipment, stands, supports, intake bonnets, flutes and all factory-primed items to receive final paint that are exposed to view in equipment rooms, on the ro of or outside the building.

C. Mechanical piping in mechanical rooms, boiler rooms, and powerhouses shall be color codes to indicate service. See HCA Piping Color Table below for recommended color scheme. For work in existing facilities, contractor is to match existing color scheme.

HCA Piping Color Table	
Piping	**Color Description**
Low Temp Supply	Dark Purple
Low Temp Return	Light Purple
Chilled Water Supply	Dark Blue
Chilled Water Return	Light Blue
Condenser Water Supply	Bright Green
Condenser Water Return	Dark Green
Hot Water Supply	Bright Red
Hot Water Return	Dark Red
Condensate	Dark Orange
Steam	Bright Orange
Natural Gas	Bright Yellow
Fuel Oil	Brown
Domestic Water	Blue

D. All piping, except for medical gas, shall be painted in exposed areas and in unconditioned areas such as loading docks, parking garages, canopies, and exterior soffits. Coordinate with architect to specify properly. Deletion of painting is not an allowable VE.

1.15 DELIVERY, STORAGE AND HANDLING

A. Refer to Division 01 and General Conditions for Delivery, Storage and Handling.

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 01 and General Conditions for Guarantees and Warranties.

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 23 that contain special warranties.

1.17 PROJECT 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, 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 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 his 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. 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. Use of explosives is not permitted.

E. 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

2.01 SOIL MATERIALS

A. Bedding Material: Provide clean sand, pea gravel or flowable fill material (per the geotechnical 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 graded crushed aggregate. Corrosive fill materials shall be not be utilized. When CL clay, rock, or gravel is used, it shall not be larger than 2 inches in any dimension and shall be free of debris, waste, frozen materials, vegetable and other deleterious matter.

C. Drainage Fill: Provide washed, evenly graded mixture of 3/4" open graded aggregate stone or gravel, around drainage pipes to a level above pipe as detailed by Architect. Provide open graded aggregate, crushed stone, crushed or uncrushed gravel with 100 percent passing a 1-1/2-inch sieve, and not more than 5 percent passing a No. 4 sieve for drainage fill to subgrade or around equipment structures.

D. Filter Fabric: Flat needle punched PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 SELECTIVE DEMOLITION

A. Refer to Division 02 and General Conditions for Selective Demolition requirements.

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."

3.04 EXCAVATION AND BACKFILLING

A. Refer to Division 01, Division 02, and Division 31, Geotechnical Soils Report and General Conditions for Excavation and Backfilling

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 and Trenching 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 and trenches for safety. Provide an adequate number of amber lights on or near the work and keep them burning from dusk to dawn. 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 and trenches to comply with Geotechnical Report, 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 and trenches regardless of time period excavations and trenches 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 of Excavation and Trenches: Prevent surface water and subsurface or ground water from flowing into excavations and trenches.

1. Do not allow water to accumulate in excavation or trenches. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations and trenches.

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.

3. 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 and trenches. 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. Excavation for Underground Tanks, Basins, and Mechanical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.
1. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.
2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

L. Trenching: Excavate trenches 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 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 sand or pea gravel prior to installation of pipe. Provide a minimum of 6 inches of sand or pea 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 bedding on undisturbed soil.

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

N. 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.

O. 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 pipes, use bedding materials in layers to 6 inches above top of the pipe.
2. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
3. Under building slabs, use subbase materials.
4. Under piping and equipment, use bedding and subbase materials over rock bearing surface and for correction of unauthorized excavation.
5. For piping less than 30 inches below surface of roadways, provide 4-inch-thick concrete protection slab. After installation and testing of pipes, provide a 4-inch thick concrete protection top slab prior to backfilling and placement of roadway subbase. Contractor shall coordinate with local AHJ as to requirements for colored concrete in this application.
6. Other areas, use excavated or borrowed materials where applicable.

7. Backfill excavations as promptly as work permits, but not until completion of the following:
    a. Inspection, testing, approval, and locations of underground utilities have been recorded.
    b. Removal of concrete formwork.
    c. Removal of shoring and bracing, and backfilling of voids.
    d. Removal of trash and debris.
8. Where gravel fill (drainage fill) is used as building fill material in lieu of natural soils, provide filter fabric material to line the trench to support the bedding fill material and subgrade materials to ensure that backfill materials will not segregate within the trench nor create voids and sags within the pipe trench.
9. Ductwork under slab shall be backfilled with a minimum of 4" bedding material on all sides for protection from soils (per Code). Subbase materials shall be utilized above the bedding material to the subgrade level.
    a. If concrete encasement is required, a minimum of 4" thickness all sides shall be provided unless otherwise noted. Contractor shall provide hold down straps as per manufacturer's recommendations.
    b. If a concrete ballast pad is required, size of ballast pad shall be as noted on the drawings or as per manufacturer's recommendations.

P. 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.

Q. Subgrade Placement and Compaction: Place subgrade 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.

R. 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.

S. 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.

T. Placement and 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 disallowed 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. 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.

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. Compaction: control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below:
6. 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 95 percent maximum density for cohesive material listed, 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 95 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 subbase backfill or fill material to 90 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

U. Subsidence: Where subsidence occurs at mechanical installation excavations and trenches 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.

3.05 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.

3.06 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.

3.07 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. Refer to Table 4 at the end of this section for a list of specification sections in Division 23 that contain special inspection requirements.
    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, 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 23 00 10

TABLE 1: MECHANICAL SPECIFICATION SHOP DRAWING SUBMITTAL REQUIREMENTS

SPECIFICATION NUMBER/TITLE		CODE DESIGNATION
230010	General Mechanical Requirements	NONE
230519	Meters and Gauges for HVAC Piping	B, H
230523	General-Duty Valves for HVAC Piping	B
230529	Hangers and Supports for HVAC Piping and Equipment	B, F, G, H
230553	Identification for HVAC Piping and Equipment	B, L, N
230593	Testing, Adjusting and Balancing For HVAC	H, J
230700	HVAC Insulation	B, L
230913	Instrumentation and Control Devices for HVAC	A, B, C, D, E, F, N, O, Q
230923	Direct-Digital Control for HVAC	A, B, C, D, E, F, J, K, L, N, O, Q
232113	Hydronic Piping	B, C, D, F, G, H, J
232116	Hydronic Specialties	A, B, C, F, G, H
232213	Steam and Condensate HVAC Piping	B, C, D, F, G, H, J
232216	Steam and Condensate Piping Specialties	A, B, C, F, G, H
233113	Metal Ducts	A, B, D, G
233300	Air Duct Accessories	A, B, F, Q
233415	Exhaust and Ventilating Fans	A, B, C, F
233600	Air Terminal Units	A, B, C, E, F
233713	Diffusers, Registers, and Grilles	A, B, C, F, M, N, Q
237413	Outdoor Central Station Air Handling Units	A, B, C, E, F, K, Q
238413	Humidifiers (Dispersion Type)	A, B, C, E, F

CODED LEGEND

A	Shop Drawings
B	Product Data
C	Performance Data, Capacities, Curves and Certificates
D	Coordination Drawings
E	Wiring Diagrams
F	Installation Instructions
G	Welder’s Certificates
H	Certificates
I	Calculations
J	Test Reports
K	Special Warranties
L	Material Samples
M	Color Samples
N	Schedules
O	Equipment List
P	Material List
Q	Recommended Spare Parts List

TABLE 2: SPARE PARTS REQUIREMENTS FOR MECHANICAL EQUIPMENT

Section Number		Received/Date/Initial
230553	Identification for HVAC Piping and Equipment	_____
232116	Hydronic Specialties	_____
232216	Steam and Condensate Piping Specialties	_____
233300	Air Duct Accessories	_____
233415	Exhaust and Ventilating Fans	
	_____	
233600	Air Terminal Units	_____
233713	Diffusers, Registers, and Grilles	_____
237413	Outdoor Packaged Heating and Cooling Units	_____

_____
Owner's Signature

TABLE 3: SPECIAL WARRANTY REQUIREMENTS FOR MECHANICAL EQUIPMENT

Section Number		Received/Date/Initial
230923	Direct Digital Control for HVAC	_____
237413	Outdoor Packaged Heating and Cooling Units	_____

TABLE 4: MECHANICAL SPECIFICATION OPERATION AND MAINTENANCE SUBMITTAL REQUIREMENTS

SPECIFICATION NUMBER/TITLE		CODE DESIGNATION
230514	Variable Frequency Drives	B, C, D, E, G, H, I
230519	Meters and Gauges for HVAC Piping	B, G, I
230529	Hangers and Supports for HVAC Piping and Equipment	B
230553	Identification for HVAC Piping and Equipment	B
230593	Testing, Adjusting and Balancing for HVAC	F
230700	HVAC Insulation	B
230913	Instrumentation and Control Devices for HVAC	A, B, C, D, E, G, H, I
230923	Direct-Digital Control for HVAC	A, B, C, D, E, F, G, H, I
232113	Hydronic Piping	A, B, C, F, G, H, I
232116	Hydronic Specialties	A, B, C, I
232213	Steam and Condensate HVAC Piping	A, B, C, F, G, H, I
232216	Steam and Condensate Piping Specialties	A, B, C, I
233113	Metal Ducts	A, B
233300	Air Duct Accessories	B, H
233416	Centrifugal HVAC Fans	B, C, G, I
233600	Air Terminal Units	B, C, D, E, G, H, I
233713	Diffusers, Registers and Grilles	C, H
237413	Outdoor Packaged Heating and Cooling Units	B, C, D, E, G, H, I
238413	Humidifiers (Dispersion Type)	B, C, D, E, G, H, I

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

SECTION 23 05 19
METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Pressure gauges and fittings.
B. Thermometers and thermometer wells.
C. Test plugs.
D. Filter gauges.

1.02 REFERENCE STANDARDS

A. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2013.
B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi; 2007.
C. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014.
D. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014.
E. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case; 2015.
F. AWWA C701 - Cold-Water Meters -- Turbine Type, for Customer Service; 2012.
G. AWWA C702 - Cold-Water Meters -- Compound Type; 2010.
H. AWWA M6 - Water Meters -- Selection, Installation, Testing, and Maintenance; 2012.
I. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.
J. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service; Current Edition, Including All Revisions.

1.03 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.
B. Product Data: Provide schedule that indicates the following for each manufactured component:
    1. Model or figure number.
    2. Use.
    3. Rating.
    4. Operating range.
    5. Total range.
    6. Calibrated performance curves, certified where indicated.
    7. Figure number.
    8. Location.
    9. Accessories.
C. Product Certificates: Signed by manufacturer certifying accuracy under specified operating conditions and product compliance with specified requirements.
D. Samples: Submit two of each type of instrument specified.
E. Project Record Documents: Record actual locations of components and instrumentation.
F. Operation and Maintenance Data: Furnish data for each manufactured component for inclusion in operating and maintenance manual.
G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
    1. Extra Pressure Gauges: One of each type and size.

1.04 FIELD CONDITIONS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.01 PRESSURE GAUGES

A. Manufacturers:
   1. Ametek, U.S. Gauge Div.
   2. Ashcroft Dresser Industries Instrument Div.
   3. Dwyer Instruments, Inc.
   4. H.O. Trerice Co.
   5. Marsh Instrument Co., Unit of General Signal.
   6. Marshalltown Instruments, Inc.
   7. Miljoco Corp.
   8. Weiss Instruments, Inc.
   9. Weksler Glass Thermometer Corp.
   10. WIKA Instruments Corp.
   11. Winters Instruments.

B. Description: ASME B40.100, UL 393, rotary brass movement, white with black markings and black pointer.

C. Case: Drawn steel, cast aluminum, or stainless steel with phosphor bronze bourdon tube and front or rear recalibration adjustment. Provide silicone fluid damping where required by Part 3.

D. Size: 4-1/2 inch diameter.

E. Lens: Clear glass.

F. Stem: Brass for separable socket, length to suit installation.

G. Scale: Progressive, satin-faced, non-reflective aluminum, permanently etched markings.

H. Accuracy: Plus or minus 1 percent of range span,.Gauges in chiller room shall be ½% accuracy.

I. Liquid-Filled: Provide glycerin liquid filled gauges in all mechanical rooms and where specified in Part 3 of this section.

2.02 PRESSURE GAUGE TAPPINGS

A. Manufacturers: Same as pressure gauge manufacturers.

B. Gauge Cock: Tee or lever handle, brass, rated for system pressure.

C. Needle Valve: Brass, 1/4 inch NPT, rated for system pressure.

D. Pulsation Damper: Pressure snubber, brass with 1/4 inch threaded connections, corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

E. Syphon: Brass, 1/4-inch NPT angle or straight pattern.

2.03 STEM TYPE THERMOMETERS

A. Manufacturers:
   1. Weiss Instruments, Inc.

B. Thermometers - Solar Digital Vari-Angle
   1. Case: High impact ABS with glass passivated thermistor, 3-1/2 inches long.
   2. Adjustable Joint: Finished to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
   3. Display: 3/8" LCD digits, wide ambient formula, 10 lux, and -40ºF to 300ºF range. Provide with an accuracy of 1%.

4. Recalibration: Internal potentiometer.
5. Stem: Stainless steel, aluminum or brass, for separable socket, length to suit installation.
   a. Minimum 6" stem where installed in air sensing applications.
6. Provide Weiss, DVU-35 with separable well or approved equal from listed manufacturer.

2.04 TEST PLUGS

A. Manufacturers:
   1. Flow Design, Inc.
   2. MG Piping Products Co.
   3. Peterson Equipment Co., Inc.
   4. Sisco, A Spedco, Inc. Co.
   5. Watts Regulator.

B. Test Plug: 1/2 inch nickel-plated brass fitting, rated for 500 psig, extension for insulation, and threaded cap with retention chain for receiving 1/8 inch outside diameter pressure or temperature probe.

C. Core Material:
   1. Neoprene core for temperatures up to 200 degrees F.
   2. Nordel core for temperatures up to 350 degrees F.
   3. Viton core for temperatures up to 400 degrees F.

D. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gauge, one gauge adapter with 1/8 inch probes, two 1 inch bimetal dial thermometers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide siphon on gauges in steam systems. Extend nipples and siphons to allow clearance from insulation.

C. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.

D. Install thermometers in air duct systems on flanges.

E. Install thermometer sockets adjacent to controls system thermostat, transmitter, or sensor sockets. Refer to Section 23 09 43. Where thermometers are provided on local panels, duct or pipe mounted thermometers are not required.

F. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

G. Coil and conceal excess capillary on remote element instruments.

H. Provide instruments with scale ranges selected according to service with largest appropriate scale.

I. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

J. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

K. Locate test plugs adjacent thermometers and thermometer sockets.

3.02 SYSTEM START-UP & COMMISSIONING

3.1 Operation & Maintenance

A. Meter Data sheets, Installation Manual, and Operation Manual shall be included in the Operation and Maintenance (O&M) documents provided for each meter type.

B. Demonstration of each meter type display is to be provided to the facility manager and his / her staff.

3.03

3.04 SCHEDULE

A. Pressure Gages, Location and Scale Range:
   1. Location: Install device at inlet and outlet of each of the following:
      a. Headers to central equipment.
      b. Heat exchangers.
      c. Pumps. Provide silicone damping gauge.
      d. Boilers.
      e. Chillers.
      f. After major coils. Reference details on plans.
      g. Expansion tanks.
      h. Pressure reducing valves.
   2. Scale Range:
      a. Vacuum: 30 inches Hg to 15 psig.
      b. All fluids: 2 times operating pressure.

B. Pressure Gage Tappings, Location:
   1. Control valves 3/4 inch & larger – inlets and outlets.
   2. Major coils – inlets and outlets.
   3. Heat exchangers – inlets and outlets.
   4. Chiller – inlets and outlets.
   5. Boiler – inlets and outlets.

C. Stem Type Thermometers, Location and Scale Range:
   1. Location: Install device at inlet and outlet of each of the following:
      a. Headers to central equipment.
      b. Heat exchangers.
      c. Boilers.
      d. Chillers.
      e. Hydronic zone supply and return.
      f. After major coils. Reference details on plans.
      g. Heat recovery unit
      h. Thermal storage tank.
   2. Scale Range:
      a. Hot Water: 30 to 300 degrees F with 2-degree scale divisions
      b. Condenser Water: 0 to 160 degrees F with 2-degree scale divisions.
      c. Chilled Water: 0 to 100 degrees F with 2-degree scale divisions.
      d. Steam and Condensate: 50 to 400 degrees F with 5-degree scale divisions.

D. Thermometer Sockets, Location:
   1. Control valves 1 inch & larger - inlets and outlets.
   2. Reheat coils - inlets and outlets.
   3. Cabinet heaters - inlets and outlets.

4. Unit heaters - inlets and outlets.

E. Dial Thermometers, Location and Scale Range:
   1. Each supply air zone, minus 32 to 150 degrees F.
   2. Outside air, minus 32 to 150 degrees F.
   3. Return air, minus 32 to 150 degrees F.
   4. Mixed air, minus 32 to 150 degrees F.

END OF SECTION 23 05 19

SECTION 23 05 23
GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Applications.
   1. General duty valves common to most mechanical piping systems.
   2. Special purpose valves are specified in individual piping system specifications.
B. General requirements.
C. Globe valves.
D. Ball valves.
E. Butterfly valves.
F. Check valves.
G. Gate valves.
H. Chainwheels.

1.02 ABBREVIATIONS AND ACRONYMS

A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene diene monomer rubber.
C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
D. NRS: Nonrising stem.
E. OS&Y: Outside screw and yoke.
F. PTFE: Polytetrafluoroethylene.
G. RS: Rising stem.
H. SWP: Steam working pressure.
I. TFE: Tetrafluoroethylene.

1.03 SUBMITTALS

A. Submit in accordance with conditions of Contract and Division 01 submittal procedures.
B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, pressure and temperature classifications, valve design, body material, seating materials, trim material, dimensions, clearances, rough-in details, weights, support requirements, and piping connections.
C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.
E. Maintenance Materials: Furnish Owner with one wrench for every five plug valves, in each size of square plug valve head.

1.04 QUALITY ASSURANCE

A. Manufacturer:
   1. Obtain valves for each valve type from a single manufacturer.
   2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.
   3. Subject to compliance requirements, provide products from one of the manufacturers listed in Valve Schedule in Part 3.

B. Valves shall be certified to meet the specified ASTM, ASME, ANSI, and MSS standards in Part 2 Products, and as follows:
   1. ASME B31.9 for building services piping.
   2. ASME B31.1 for power piping.

C. Welding Materials and Procedures: Conform to ASME BPVC-IX.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
   2. Protect valve parts exposed to piped medium against rust and corrosion.
   3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
   4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
   5. Secure check valves in either the closed position or open position.
   6. Adjust butterfly valves to closed or partially closed position.

B. Use the following precautions during storage:
   1. Maintain valve end protection and protect flanges and specialties from dirt.
      a. Provide temporary inlet and outlet caps.
      b. Maintain caps in place until installation.
   2. Store valves in shipping containers and maintain in place until installation.
      a. Store valves indoors in dry environment.
      b. Store valves off the ground in watertight enclosures when indoor storage is not an option.

C. Exercise the following precautions for handling:
   1. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products from one of the manufacturers listed in the Valve Schedule in Part 3.

2.02 APPLICATIONS

A. Provide the following valves for the applications if not indicated on Drawings:
   1. Throttling (Hydronic): Butterfly, Ball, and Globe.
   2. Throttling (Steam): Globe.
   3. Isolation (Hydronic): Butterfly, Gate, Ball, and Globe.
   4. Isolation (Steam): Gate and Ball.
   5. Dead-End: Butterfly and Ball.

B. Substitutions of valves with higher CWP classes or SWP ratings for same valve types are permitted when specified CWP ratings or SWP classes are not available.

C. Required Valve End Connections for Non-Wafer Types:
   1. Steel Pipe:
      a. 2 NPS and Smaller: Threaded ends.
      b. 2-1/2 NPS and Larger: Grooved or flanged ends.
   2. Copper Tube:
      a. 2 NPS and Smaller: Threaded or solder-joint valve ends.
         1) Exception: Solder ends not acceptable for hot water or steam pipe.

b. 2-1/2 NPS and Larger: Grooved or flanged ends.

3. Steam and Steam Condensate Pipe: Solder and grooved ends not acceptable.

D. Chilled Water Valves:

1. 2 NPS and Smaller:
   a. Minimum Class: 125.
   b. Body: Bronze.
   c. Allowable Valve Types:
      1) Ball: Two piece.
      2) Lift check.
      3) Swing check.
      4) Wafer plate-type check.
2. 2-1/2 NPS and Larger:
   a. Minimum Class: 125.
   b. Body: Cast iron, except as noted below.
   c. Allowable Valve Types:
      1) Butterfly: Ductile iron body.
      2) Lift check.
      3) Swing check.
      4) Wafer plate-type check.

E. Condenser Water Valves:

1. 2 NPS and Smaller:
   a. Minimum Class: 125.
   b. Body: Bronze.
   c. Allowable Valve Types:
      1) Ball: Two piece.
      2) Lift check.
      3) Swing check.
      4) Wafer plate-type check.
2. 2-1/2 NPS and Larger:
   a. Minimum Class: 125.
   b. Body: Cast iron, except as noted below.
   c. Allowable Valve Types:
      1) Butterfly: Ductile iron body. Furnish aluminum bronze or stainless steel disc in open loop systems.
      2) Lift check.
      3) Swing check.
      4) Wafer plate-type check.

F. Heating Hot Water Valves:

1. 2 NPS and Smaller:
   a. Minimum Class: 125.
   b. Body: Bronze.
   c. Allowable Valve Types:
      1) Ball: Two piece.
      2) Lift check.

3) Swing check.
4) Wafer plate-type check.

2. 2-1/2 NPS and Larger:
   a. Minimum Class: 125.
   b. Body: Cast iron, except as noted below.
   c. Allowable Valve Types:
      1) Butterfly: Ductile iron body.
      2) Lift check.
      3) Swing check.
      4) Wafer plate-type check.

G. Low Pressure Steam Valves (15 PSIG or Less):
   1. 2 NPS and Smaller:
      a. Minimum Class: 150.
      b. Body: Bronze.
      c. Allowable Valve Types:
         1) Ball: Two piece, Class 250, 600 psig CWP.
         2) Lift check.
         3) Swing check.
         4) Wafer plate-type check.
   2. 2-1/2 NPS and Larger:
      a. Minimum Class: 150.
      b. Body: Cast iron, except as noted below.
      c. Allowable Valve Types:
         1) Lift check.
         2) Wafer plate-type check.
         3) Gate.

H. High Pressure Steam Valves (Greater than 15 PSIG):
   1. 2 NPS and Smaller:
      a. Minimum Class: 200
      b. Body: Bronze.
      c. Allowable Valve Types:
         1) Swing Check.
         2) Gate.

2.03 GENERAL REQUIREMENTS

A. Mechanically Joined General Duty Valves:
   1. Contractor may provide mechanically joined general duty valves as an option in lieu of, in whole of, or in part of, the general duty valve fitting and joining methods for the specific systems indicated in Article “Applications.” Reference Division 23 Section “Mechanically Joined Hydronic Piping Systems.”
   2. Contractor shall not use mechanically joined general duty valves for hydronic piping in lieu of welded, threaded or flanged valves.

B. Ball Valves on reheat coils shall be provided with memory stops

C. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.

D. Valve Sizes: Match upstream piping unless otherwise indicated.

E. Valve Stem Design:
   1. Rising stem or rising outside screw and yoke stems.
   2. Non-rising stem valves may be used on water systems where headroom prevents full extension of rising stems.

F. Valve Actuator Types:
   1. Gear Actuator: Quarter-turn valves 8 NPS and larger.
   2. Handwheels: Valves other than quarter-turn types.
   3. Hand Lever: Quarter-turn valves 6 NPS and smaller, vinyl-covered.
   4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the “Valve Installation” Article.

G. Valves in Insulated Piping: Provide stem extensions so valve operator extends a minimum of 1/2 inches outside of the insulation and the following features:
   1. Gate Valves: Rising stem.
   2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   3. Butterfly Valves: Extended neck.
   4. Memory Stops: Fully adjustable after insulation is installed.

H. Valve-End Connections:
   1. Threaded End Valves: ASME B1.20.1.
   2. Flanges: ASME B16.1 for cast iron.
   3. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5 for steel, ASME B16.24 for bronze.
   4. Solder Joint Connections: ANSI B16.18.
   5. Grooved End Connections: AWWA C606.

I. General ASME Compliance:
   1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
   2. Power Piping Valves: ASME B31.1.
   3. Building Services Piping Valves: ASME B31.9.

J. Bronze Valves:
   1. Fabricate from dezincification resistant material.
   2. Copper alloys containing more than 15 percent zinc are not permitted.

K. Valve Bypass and Drain Connections: MSS SP-45.

L. Source Limitations: Obtain each valve type from a single manufacturer.

2.04 BRONZE GLOBE VALVES

A. Class 150, 300 psig CWP:
   1. Comply with MSS SP-80, Type 2, nonmetallic disc to metal seat.
   2. Body: Bronze; ASTM B62, with integral seat and union bonnet.
   3. Ends: Threaded or solder joint.
   4. Stem and Disc: Bronze stem, PTFE disc.
   5. Packing: Asbestos free, brass gland.
   6. Operator: Malleable iron handwheel.

2.05 IRON GLOBE VALVES

A. Class 125, 200 psig CWP and Class 250, 500 psig CWP: 2 ½” and larger
   1. Comply with MSS SP-85, Type 1.

2. Body: Gray iron; ASTM A126, with bolted bonnet.
3. Ends: Grooved or flanged.
4. Trim: Bronze.
5. Packing and Gasket: Asbestos free, two-piece backing gland assembly.
6. Operator: Handwheel or chainwheel.

2.06 BRONZE BALL VALVES

A. Two Piece, Class 150, for valves 2 inch and smaller:
1. Comply with MSS SP-110.
2. CWP Rating: 600 psi.
3. Body: Bronze, ASTM B584.
4. Trim: Bronze.
5. Ends: Threaded or solder joint.
6. Seats and Seals: PTFE.
7. Stem: Blowout-proof.
8. Ball: Full port, ASTM A276 Type 316 stainless steel.
9. Operator: Vinyl-covered steel handle.

2.07 TWO PIECE, CLASS 250 VALVES

A. Two Piece, Class 150, for valves 2 inch and smaller:
1. Comply with MSS SP-110.
2. SWP Rating: 250 psig.
3. CWP Rating: 600 psig.
4. Body: Bronze, ASTM B61.
5. Trim: Bronze.
6. Ends: Threaded.
7. Seats and Seals: PTFE.
8. Stem: Stainless steel, blowout-proof.
9. Ball: Full port, ASTM A276 Type 316 stainless steel, vented.
10. Operator: Vinyl-covered steel handle.
11.

2.08 IRON BUTTERFLY VALVES

A. Lug type: Bi-directional dead-end service without downstream flange.
1. Comply with MSS SP-67, Type I.
2. CWP Rating: 200 psig and 250 psig.
3. Body Material: ASTM A536 ductile iron.
4. Stem: One or two-piece stainless steel.
5. Seat and Seal: EPDM.
6. Disc: Aluminum-bronze, stainless steel, or one-piece Nylon-coated ductile iron.
7. Operator:
a. Size less than 8 inches: Lever operator, 10 position minimum, with locks and stops.
b. Size 8 inch and larger: Gear type with position indicator.

2.09 BRONZE LIFT CHECK VALVES

A. Class 150:
1. Comply with MSS SP-80, Type 2, Nonmetallic Disc to Metal Seat.
2. CWP Rating: 200 psig.

3. Design: Horizontal or angle pattern, capable of being refitted and ground while valve remains in the line.
4. Body: Bronze, ASTM B62.
5. Ends: Threaded.
6. Spring: Stainless steel.
7. Disc: PTFE.

2.10 BRONZE SWING CHECK VALVES

A. Class 125:
1. Comply with MSS SP-80, Type 3.
2. CWP Rating: 200 psig.
3. Design: Horizontal swing, Y-pattern, capable of being refitted and ground while valve remains in the line.
4. Body: Bronze, ASTM B62.
5. Ends: Threaded or solder joint.
6. Disc: PTFE.

B. Class 150:
1. Comply with MSS SP-80, Type 3.
2. CWP Rating: 300 psig.
3. Design: Horizontal swing, Y-pattern, capable of being refitted and ground while valve remains in the line.
4. Body: Bronze, ASTM B62.
5. Ends: Threaded.
6. Disc: PTFE.

C. Class 200:
1. Comply with MSS SP-80, Type 3.
2. CWP Rating: 400 psig.
3. Design: Horizontal swing, Y-pattern, capable of being refitted and ground while valve remains in the line.
4. Body: Bronze, ASTM B61.
5. Ends: Threaded.
6. Disc: Bronze.

2.11 IRON, FLANGED END SWING CHECK VALVES

A. Class 125, 200 psig CWP.
1. Comply with MSS SP-71, Type I.
2. Design: Horizontal swing, clear or full waterway, capable of being refitted and ground while valve remains in the line.
3. Body: Cast iron with bolted bonnet in accordance with ASTM A126, Class B.
4. Ends: Flanged.
5. Trim: Bronze.
6. Disc Holder: Bronze face ring and seat ring.
7. Disc: Bronze or ductile iron.
8. Gasket: Asbestos free.

B. Class 250, 500 psig CWP.
1. Comply with MSS SP-71, Type I.

2. Design: Horizontal swing, clear or full waterway, capable of being refitted and ground while valve remains in the line.
3. Body: Cast iron with bolted bonnet in accordance with ASTM A126, Class B.
4. Ends: Flanged.
5. Trim: Bronze.
6. Disc Holder: Bronze face ring and seat ring.
7. Disc: Bronze or ductile iron.
8. Gasket: Asbestos free.

2.12 IRON, WAFER PLATE-TYPE CHECK VALVES

A. Class 125 Dual-Plate (Twin Disc):
1. Comply with API STD 594.
2. 2-1/2 NPS to 12 NPS, CWP Rating: 200 psig.
3. 14 NPS to 24 NPS, CWP Rating: 150 psig.
4. Design: Wafer, non-slam, spring-loaded plates, designed to open and close at approximately 0.5 psi differential.
5. Body: ASTM A126, cast iron.
6. Ends: Flanged.
7. Trim: Stainless steel.
8. Disc: Replaceable bronze.
9. Seat: EPDM, or NBR.

B. Class 250 Dual-Plate (Twin Disc):
1. Comply with API STD 594.
2. 2-1/2 NPS to 12 NPS, CWP Rating: 400 psig.
3. 14 NPS to 24 NPS, CWP Rating: 300 psig.
4. Design: Wafer, non-slam, spring-loaded plates, designed to open and close at approximately 0.5 psi differential.
5. Body: ASTM A126, cast iron.
6. Ends: Flanged.
7. Trim: Stainless steel.
8. Disc: Bronze.
9. Seat: EPDM, or NBR.

2.13 BRONZE GATE VALVES

A. Class 150:
1. Comply with MSS SP-80, Type I.
2. CWP Rating: 300 psig.
3. Body: Bronze, ASTM B61 with integral seat and union-ring bonnet.
4. Trim: Bronze.
5. Ends: Threaded.
6. Stem: Bronze, RS type. NRS type where exceptions apply.
7. Disc: Solid wedge; bronze.
8. Packing: Asbestos free, brass.
9. Operator: Malleable iron handwheel.

B. Class 300:
1. Comply with MSS SP-80, Type I.

2. CWP Rating: 600 psig.
3. Body: Bronze, ASTM B61 with integral seat and union-ring bonnet.
4. Trim: Bronze.
5. Ends: Threaded.
6. Stem: Bronze, RS type. NRS type where exceptions apply.
7. Disc: Solid wedge; bronze with stainless steel seat ring.
8. Packing: Asbestos free.
9. Operator: Malleable iron handwheel.

2.14 IRON GATE VALVES

A. Class 250:
1. Comply with MSS SP-70, Type I.
2. 2-1/2 NPS to 12 NPS, CWP Rating: 500 psig.
3. 14 NPS to 24 NPS, CWP Rating: 300 psig.
4. Body: Cast iron, ASTM A126 Class B with bolted bonnet.
5. Ends: Flanged.
6. Trim: Bronze.
7. Stem: OS&Y, RS type. NRS type where exceptions apply.
8. Disc: Solid wedge.
9. Packing and Gasket: Asbestos free, 2-piece packing gland assembly.
10. Operator: Malleable iron handwheel.

2.15 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Sprocket Rim with Chain Guides: Ductile iron include zinc coating.
3. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Discard all packing materials and verify that valve interior, including threads and flanges are completely clean without signs of damage or degradation that could result in leakage.
B. Verify valve parts to be fully operational in all positions from closed to fully open.
C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.
D. If valve is determined to be defective, replace with new valve.

3.02 INSTALLATION

A. Install products in accordance with manufacturer’s instructions.
B. Locate valves for easy access. Provide access doors and fire rated access doors as required.
C. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
D. Install shut-off duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.
E. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.
F. Install three-valve bypass around each pressure reducing valve using throttling-type valves.

G. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.

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

I. Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

J. Valves with soldered end connections:

1. Use solder with a melting point as follows:

a. Below 840 degrees F for gate, globe, and check valves.

b. Below 421 degrees F for ball valves.

K. Install check valves where necessary to maintain direction of flow as follows:

1. Lift Check: Install with stem plumb and vertical.

2. Swing Check: Install horizontal maintaining hinge pin level.

3. Orient plate-type into horizontal or vertical position, between flanges.

L.

M. Provide Clamp lock hand lever operators on valves less than 8". Provide hand wheel and closed housing worm gear on valves 8" and larger

N. Provide chainwheels on operators for valves 4 NPS and larger where located 72 inches or more above finished floor in mechanical rooms, terminating 60 NPS above finished floor.

3.03 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 leak; replace valves if leak persists.

3.04 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.

3.05 VALVE SCHEDULE

A. Bronze Globe Valves, Class 150:

MANUFACTURER	THREADED NRS	THREADED RS	SOLDER RS
Milwaukee	--	590T	1590T
Nibco	--	T-235-Y	S-235-Y

B. Bronze Globe Valves, Class 200:

MANUFACTURER	THREADED RS
Milwaukee	592A
Nibco	T-256-AP

C. Bronze Ball Valves – 2 inch and smaller, Class 150:

1. Model for chrome plated brass ball indicated. Furnish SS ball if specified in Part 2.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Apollo	77C-140	77C-240
Hammond	8301A	8311A

Milwaukee	BA-400	BA-450
Nibco	T-585-70	S-585-70
Watts	LFB6080G2	LFB6081G2

D. Bronze Ball Valves, Class 250:

MANUFACTURER	THREADED ENDS
Apollo	70-140-64
Nibco	T-585-70-66-ST

E. Iron Butterfly Valves, 200 psig CWP:

MANUFACTURER	SERIES
Apollo	LD141
Crane Center Line	44
Keystone	222
Nibco	LD-2000
Hammond	6411

F. Iron Butterfly Valves, 250 psig CWP:

MANUFACTURER	SERIES
Keystone	Paraseal
Nibco	LD-3000

G. Bronze Lift Check Valves, Class 150:

MANUFACTURER	HORIZONTAL
Crane	27TF

H. Bronze Swing Check Valves:

MANUFACTURER	CLASS 125 THREADED	CLASS 125 SOLDER	CLASS 150 THREADED	CLASS 200 THREADED
Apollo	163T	163S	164T	169T
Milwaukee	509-T	1509-T	510-T	508
Nibco	T-413-Y	S-413-Y	T-433-Y	T-453-B

I. Iron Flanged End Swing Check Valves:

MANUFACTURER	CLASS 125	CLASS 250
Apollo	910F	920F
Crane	373	39E
Milwaukee	F2974	F2970
Nibco	F-918-B	F-968-B

J. Iron Wafer Plate-Type Check Valves:

MANUFACTURER	CLASS 125	CLASS 250
Apollo	910WB	910WE
Center Line	800	--
Crane	DuoChek II G12HAP	DuoChek G25
Metraflex	CVOSSXXX	CVOSSXXX
Nibco	W-920-W	W-960-W

K. Bronze Gate Valves, Class 125:

MANUFACTURER	THREADED	THREADED	SOLDER	SOLDER

	NRS	RS	NRS	RS
Apollo	102T	101T	102S	101S
Crane	438	428	--	--
Milwaukee	105	148	115	149
Nibco	T113	T111	S113	S111

L. Bronze Gate Valves, Class 150:

MANUFACTURER	THREADED NRS	THREADED RS	SOLDER NRS	SOLDER RS
Apollo	106T	107T	--	--
Crane	437	431	1324	1334
Milwaukee	1141	1151	--	1169
Nibco	T-136	T-134	S-136	S-134

M. Iron Gate Valves, Class 250:

MANUFACTURER	OS&Y RS	NRS
Apollo	621F	620F
Milwaukee	F2894A	--
Nibco	F-667-0	F-669

END OF SECTION 23 05 23

1.01 **SECTION 230529**

1.02

1.03 **SUPPORTS, ANCHORS AND ISOLATORS**

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Horizontal-piping hangers and supports.
2. Vertical-piping clamps.
3. Hanger-rod attachments.
4. Welded steel brackets.
5. Spring cushions.
6. Saddles and shields.
7. Roof mounted duct, pipe and equipment supports.
8. Equipment spring isolators.
9. Neoprene pad supports.
10. Miscellaneous materials.

B. Supports specific to individual mechanical and plumbing systems and included in other Divisions and Sections.

1.2 DEFINITIONS

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

1.3 SUBMITTALS

A. Product data, including dimensions, materials and installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, application and features for each required pipe hanger and support.

1. Application schedule to include pipe or duct system, size, hanger and/or support type with accessories, support spacing and building attachments. Include manufacturer and model number in schedule.

1.4 QUALITY ASSURANCE

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

B. NFPA Compliance: Hangers and supports shall comply with NFPA Standard No. 13 and 14 when used as a component of a fire protection system.

C. UL and FM Compliance: Hangers, supports, and components shall be listed and labeled by UL and FM where used for fire protection piping systems.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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 supports shall be copper or shall have a nonmetallic coating for electrolytic protection where attachments are in direct contact with un-insulated copper.

B. Horizontal Piping Hangers and Supports:

1. Adjustable Steel Clevis Hanger: MSS Type 1. Use for all sizes of insulated piping, and all uninsulated piping larger than 3-inch diameter, except for steam and condensate pipe.

2. Adjustable Roller Hanger: MSS Type 43. Use for all steam piping and all condensate pipe supported from above.

3. Adjustable Steel Band Hanger: MSS Type 7. Use for un-insulated steel pipe 3-inch diameter and smaller.

4. Adjustable Copper Band Hanger: MSS Type 9. Use for uninsulated copper piping 3-inch diameter or less.

5. Pipe Saddle Support: MSS Type 37, including steel pipe base support and cast-iron floor flange with U-bolt pipe restraint.

6. Adjustable Pipe/Equipment Saddle Support: MSS Type 38, including steel pipe base support and cast-iron floor flange.

7. Adjustable Pipe Roller and Base: MSS Type 46, suitable for outdoor installation. Use where indicated on the drawings.

8. Wall Brackets: MSS Type 31, 32 or 33 welded steel securely anchored to wall substrate.

9. U-Bolts: MSS Type 24.

C. Vertical Piping Clamps:

1. Riser Clamp: MSS Type 8.

2. Pipe Clamps with Spring Support: Amber/Booth Type SWP with base plate and mounting bolt holes, adjusting nut, top plate and riser clamp.

a. Provide where indicated on the drawings.

D. Hanger Rod Attachments:

1. Steel Turnbuckle: MSS Type 13.

E. Welded Steel Brackets:

1. MSS Type 31, 32 or 33, as required by loading.

F. Spring Cushions:

1. MSS Type-48. Use for top of vertical pipe risers, all refrigerant piping, support of unit heaters, fan coil units, cabinet unit heaters, computer room units, horizontal in-line fans, generator exhaust pipe and mufflers, and elsewhere where specified or shown on the drawings.

G. Saddles and Shields:

1. Protective Shield: MSS Type 40, galvanized, length and gauge as recommended by manufacturer to prevent crushing of insulation or at minimum per Part 3 of this Section.

2. Saddles for Steam Pipe: MSS Type 39A or 39B, steel, welded to pipe, length as recommended by manufacturer and sized to match pipe insulation thickness.

H. Equipment Spring Isolators: Provide, where not provided by equipment manufacturers, housed steel springs with leveling bolts, base pad, and base plate with bolt holes predrilled. Provide number and size required for equipment supported. Provide products from one of the following Manufacturers.

1. Mason Industries
2. Korfund
3. Amber Booth
4. Vibro-Acoustics

I. Inertia Bases: Welded steel channel frame with steel reinforcing bars 8 inches on center welded to frame, minimum 3-1/2-inch depth. Fill with 3000 psi concrete with equipment anchor bolts set in concrete. Provide brackets welded to frame for attachment of spring isolators.

J. Neoprene Pad Supports: Ribbed neoprene, 3/8" thickness, Amber/Booth "Ampad" Type NR or approved equal.

2.2 MISCELLANEOUS MATERIALS

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

2.3 ROOF MOUNTED DUCT, PIPE AND EQUIPMENT SUPPORTS

A. Provide shop fabricated equipment supports for roof mounted ducts, pipes and equipment where indicated on the drawings.

B. Fabricate support using 18-gauge galvanized steel, with wood nailer.

C. Provide shims and base plate, as required to level and to make support compatible with

roofing system.

D. Construct dimensions required by equipment, pipe or duct supported.

E. Unistrut model Unipier roof pipe and duct supports.

F. Dura-Bloc model BD roof pipe and duct supports.

G. Thycurb Model TEMS-3 or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions under which supports, and anchors are to be installed. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Install hangers, supports, clamps and attachments to support piping properly from building structure (beams and joists); comply with MSS SP-69 and SP- 89. Arrange for grouping of parallel runs of horizontal piping supported together on field- fabricated, heavy-duty trapeze where possible. Where piping of various sizes is supported together by trapeze, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.

B. Install additional supports at concentrated loads, as shown on drawings, and including equipment, valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping.

C. Support from Structural Steel: Liquid filled piping may be supported directly off of the structural framing members as outlined below. Where pipes are supported or hung from steel joists or beams, the supports or hangers shall not be hung from or fastened to the bottom chord of the joists or flange of beam but shall be supported and fastened to the top chord of the joists or flange of beam. Only clamps or fasteners manufactured for this purpose may be used. Where runs of piping are parallel to the joists or beams and are located between joists or beams, pre-fabricated support channels shall be installed to span between the joist top chords or beam flanges for support of hangers. Channel supports shall be attached to joist top chords or beam flanges as described above.

D. Use of Hanger Tabs: Hanger tabs provided as an integral part of the composite steel floor deck shall be used for support of ceiling loads only. Piping, wiring, ductwork and other mechanical loads shall not be suspended from these hanger tabs.

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

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

G. Pipe Slopes: Install hangers and supports to provide pipe slopes where specified or required.

H. Insulated Piping: Install protective shields MSS Type 40. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS (GAUGE)
1/2 through 3	12	0.048 (18)
4	12	0.060 (16)
5 and 6	18	0.060 (16)
8 through 14	24	0.075 (14)
16 through 24	24	0.105 (12)

1. Insert material shall be at least as long as the protective shield. Provide insert on all piping 1 inch and larger. All piping shall have insert material per Specification Section 230700.

2. Steam and condensate piping shall have a welded steel saddle when installed on pipe roller supports.

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

3.3 SPACING OF HORIZONTAL PIPE HANGERS:

A. Except as otherwise specified in individual pipe sections or shown on the drawings, provide pipe hangers spaced no greater than that shown in following table:

PART 2 - STEEL PIPE SUPPORTS

Pipe Size	Max. Span	Min. Rod Size
3/4”	7 ft.	3/8”
1”	7 ft.	3/8”
1-1/4”	7 ft.	3/8”
1-1/2”	9 ft.	3/8”
2”	10 ft.	3/8”
2-1/2”	10 ft.	1/2”
3”	12 ft.	1/2”
4”	14 ft.	5/8”
5”	16 ft.	5/8”
6”	17 ft.	3/4”
8”	19 ft.	7/8”
10”	20 ft.	7/8”
12”	23 ft.	7/8”
14”	25 ft.	1”
16”	27 ft.	1”
18”	28 ft.	1-1/4”
20”	30 ft.	1-1/4”

Copper Pipe Supports

Pipe Size	Max. Span	Min. Rod Size

1/2”	4 ft.	3/8”
3/4”	5 ft.	3/8”
1”	6 ft.	3/8”
1-1/4”	6 ft.	3/8”
1-1/2”	8 ft.	3/8”
2”	8 ft.	3/8”
2-1/2”	9 ft.	1/2”
3”	10 ft.	1/2”
4”	10 ft.	1/2”

B. Vertical Support:

1. Support vertical piping at each floor or roof.

3.4 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. Install powder actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

D. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

3.5 ADJUSTING

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

END OF SECTION 230529

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Adhesive-backed duct markers.

D. Stencils.

E. Pipe markers.

F. Ceiling tacks.

G. Engraved plastic-laminate signs.

1.02 SUBMITTALS

A. Custom Signage: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

B. Valve Tag Schedule: Submit 8-1/2 x 11 inch typewritten valve schedule. Furnish one extra copy for each maintenance manual. Include the following information in the schedule:

1. Valve tag number.
2. Piping system and system abbreviation as shown on tag.
3. Location of valve (room or space).
4. Variations for identification (if any).
5. Function. Specially mark valves which are intended for emergency shut-off and similar special uses in margin of schedule.
6. Valve manufacturer's name and model number.

C. Product Data: Submit manufacturer's technical product data for each product required.

D. Manufacturer’s Installation Instructions: Indicate special procedures and installation for each product required.

1.03 SPARE PARTS

A. Furnish minimum of 5 percent extra stock of each mechanical identification material required for each system that uses the identification material.

B. Furnish not less than 3 additional numbered valve tags for each piping system.

C. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock along with stenciling paints and applicators.

PART 2 - PRODUCTS AND MATERIALS

2.01 ACCEPTABLE MANUFACTURERS

A. Advanced Graphic Engraving, LLC.

B. Brady Corporation.

C. Brimar Industries, Inc.

D. Craftmark.

E. Industrial Safety Supply Co., Inc.

F. Kolbi Pipe Marker Co.

G. MIFAB, Inc.

H. Seton Identification Products, a Tricor Direct Company..

2.02 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, stencils, or engraved plastic laminate signs.

C. Air Terminal Units: Tags, stencils, or engraved plastic laminate signs.

D. Automatic Controls: Tags, use the same naming convention coordinated with the building automation system.

E. Control Panels: Nameplates.

F. Dampers: Ceiling tacks where located above lay-in ceiling. Do not use ceiling tacks in a gyp ceiling.

G. Ductwork: Adhesive-backed duct markers. Stencils are only acceptable for concealed ductwork, exterior ductwork, or in mechanical rooms.

H. Fans: Nameplates, stencils, or engraved plastic laminate signs.

I. Heat Transfer Equipment: Nameplates, stencils, or engraved plastic laminate signs.

J. Humidifiers: Nameplates or engraved plastic laminate signs.

K. Instrumentation: Tags.

L. Major Control Components including Variable Frequency Drives: Nameplates or engraved plastic laminate signs.

M. Piping: Pipe Markers.

N. Pumps: Nameplates or engraved plastic laminate signs.

O. Relays: Tags.

P. Small-sized Equipment: Tags.

Q. Tanks: Nameplates or engraved plastic laminate signs.

R. Thermostats: Nameplates.

S. Valves: Tags. Ceiling tacks are acceptable where located above a lay-in ceiling. Do not use ceiling tacks in a gyp ceiling.

T. Water Treatment Devices: Nameplates or engraved plastic laminate signs.

U. General Signs: Engraved plastic laminate signs.

2.03 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. Hazardous equipment: Colors and designs recommended by ASME.
6. Equipment and components that do not meet any of the above criteria: Blue.

F. Plastic: Conform to ASTM D709.

2.04 TAGS

A.

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. Tag Fasteners: Solid brass chain (wire link or beaded type), or solid brass S-hooks of the size required for proper attachment of tags to valves, manufactured specifically for that purpose.

E. Valve Tag Chart: Typewritten letter size list in anodized aluminum or finished hardwood frame, covered with SSB-grade sheet glass. Provide frame and mounting screws for removable mounting.

F. Letter Height:

1. System Abbreviation: Minimum 1/4 inch.
2. Valve Number: Minimum 1/2 inch.

2.05 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.

2.06 STENCILS

A. Stencils: With clean cut symbols and letters of following size, complying with ASME A13.1:

1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.

2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.

3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.

4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.

5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.

6. Ductwork and Equipment: 2-1/2 inch high letters.

7. Access Doors: 3/4 inch high letters.

8. Operational Instructions: 3/4 inch high letters.

9. Provide arrows indicating direction of flow.

B. Stencil Paint: Oil based, alkyd enamel, either brushing grade or pressurized spray-can form and grade, black color, except for piping. For piping systems use colors conforming to ASME A13.1.

2.07 PIPE MARKERS

A. 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.

B. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

1. Detection: Provide multi-ply tape consisting of solid aluminum foil core between two layers of plastic ribbon tape.

C. 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 selected by the Engineer.

D. Arrows: Provide pipe markers with integral arrows indicating direction of flow or as a separate unit of plastic.

E. Color:

1. Conform to ASME A13.1.
2. Heating, Cooling, and Boiler Feedwater: Green with white letters.
3. Toxic and Corrosive Fluids: Orange with black letters.
4. Compressed Air: Blue with white letters.

F. Letter Height: Minimum 1/2 inch for pipes up to 3 inch, minimum 1 inch for larger pipes.

2.08 CEILING TACKS

A. Description: Steel with 3/4 inch diameter color coded head.

B. Color:

1. HVAC Equipment: Yellow.
2. Fire Dampers and Smoke Dampers: Red.
3. Heating/Cooling Valves: Blue.

2.09 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Engraving stock melamine plastic laminate, 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. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

D. Nomenclature: When used to identify equipment, match terminology on schedules, including the following:

1. Name and mark number.
2. Equipment service.
3. Design capacity.

E. 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

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Division 09 for stencil painting.

3.02 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 tags on piping 3/4 inch diameter and smaller.

E. Install in clear view and align with axis of piping.

F. Apply stencil painting in accordance with Division 09.

G. Identify service, flow direction, and pressure.

3.03 PIPING IDENTIFICATION

A. General: Install identification on the most obviously visible portion of the pipe from the point of access.

A. Color-coded plastic wrap-around labels are an acceptable alternative to painting on insulated pipe. Plastic labels shall only be applied in accordance with code-limitations for smoke developed and flame spread ratings.

B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

C. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe during back-filling/top-soiling of each underground piping system, Where multiple pipes are buried in common trench and do not exceed overall width of 16 inches, install single pipe marker. For tile fields and similar artificial field installations, mark only edge pipe lines of field.

D. Pipes less than 6 inches diameter (including insulation):, Provide full-band pipe markers with 360 degree coverage.

E. Pipes 6 inches diameter and larger (including insulation): Provide either full-band or strip-type pipe markers

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

1. Fuel oil piping (indicate supply and return systems, accordingly).
2. Chilled water piping (indicate supply and return systems, accordingly).
3. Heating water piping (indicate supply and return systems, accordingly).
4. Condenser water piping (indicate supply and return systems, accordingly).
5. Steam piping (indicate PSI of systems, accordingly).
6. Steam condensate piping (indicate high, medium and low pressure systems, accordingly).
7. Refrigerant piping (indicate liquid and suction systems, accordingly).

G. 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 20 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.

H. Mechanical piping in mechanical rooms, boiler rooms, and powerhouses shall be color codes to indicate service. See HCA Piping Color Table below for recommended color scheme. For work in existing facilities, contractor is to match existing color scheme.

HCA Piping Color Table	
Piping	**Color Description**
Low Temp Supply	Dark Purple
Low Temp Return	Light Purple
Chilled Water Supply	Dark Blue
Chilled Water Return	Light Blue
Condenser Water Supply	Bright Green
Condenser Water Return	Dark Green
Hot Water Supply	Bright Red
Hot Water Return	Dark Red
Condensate	Dark Orange
Steam	Bright Orange
Natural Gas	Bright Yellow
Fuel Oil	Brown
Domestic Water	Blue

1.

3.04 VALVE IDENTIFICATION

A. General: Valve tags are required for all emergency shutoff valves and all manual valves 1″ and larger. Emergency shutoff valves shall include all valves 2″ and larger for the following services: domestic hot and cold water, chilled water, heating hot water, steam and steam condensate and natural gas. Mark ceiling grid with colored marker indicating valve locations above the ceiling.Mount valve tag chart and schedule frame in mechanical room, or where indicated on plans. If not indicated, mount where directed by Engineer. Where more than one mechanical room is included on the project, mount framed copies of valve tag chart and schedule in each mechanical room.

3.05 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.

3.06 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.

3.07 CEILING TACK INSTALLATION

A. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

3.08 EQUIPMENT IDENTIFICATION

A. Install nameplates and engraved plastic laminate signs for identification of equipment. 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. Less than 2 feet: Minimum 1/4 inch.
2. Up to 6 feet: Minimum 1/2 inch.
3. Greater than 6 feet: Proportionally increase letter size based on recommendations above.
4. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.
5. 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. CAV/VAV terminal units concealed above lay-in ceilings shall be marked by a marker clipped to the grid.

END OF SECTION 23 05 53

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General testing, adjustment, and balancing requirements.

B. Pre-testing, adjustment, and balancing of existing air systems.

C. Pre-testing, adjustment, and balancing of existing hydronic systems.

D. Testing, adjustment, and balancing of air systems.

E. Testing, adjustment, and balancing of hydronic systems.

F. Testing, adjustment, and balancing of domestic water systems.

G. Testing, adjustment, and balancing of steam systems.

H. Sound and vibration measurement of equipment operating conditions.

I. This section excludes:

1. Testing boilers and pressure vessels for compliance with safety codes;

2. Specifications for materials for patching mechanical systems;

3. 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.

4. Requirements and procedures for piping and ductwork systems leakage tests.

1.02 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.

1.03 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. Progress Reports.

F. 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. Hydronic Systems

d. Temperature Control Systems

e. Special Systems

f. Sound and Vibration 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.

G. Project Record Documents: Provide drawings that record actual locations of flow measuring stations and balancing devices.

1.04 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. The TAB Contractor shall be a sub-contractor to the General Contractor and be financially independent from all other sub-contractors associated with the project.

4. The Mechanical Contractor shall coordinate his work with the TAB Contractor and correct any system deficiency identified in the General Contractor’s and TAB Contractor’s inspection.

5. Specify that TAB Contractor shall be an active participate in the commissioning process as specified in Section 01 91 13.

6. Have a minimum of 5 years documented experience on projects with TAB requirements similar to those required for the project.

7. Certified by one of the following Certification Associations:

a. NEBB: National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

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.

PART 2 - PRODUCTS AND MATERIALS – NOT USED

PART 3 - EXECUTION

3.01 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 hydronic, steam, 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.

3.02 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.
14. Hydronic systems are flushed, filled, and vented.
15. Hydronic systems are tested for leaks.
16. Test ports, gauge cocks, thermometer wells, flow-control devices, and balancing valves are properly installed and that their location is accessible.
17. Pumps are rotating correctly.
18. Proper strainer baskets are clean and in place.
19. Service and balance valves are open.
20. Expansion tanks are not air bound and have appropriate charge.
21. Air vents are operating freely.

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.

3.03 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.

3.04 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 individual Supply terminal devices and branch lines to ± 10 percent and main ducts and air handling equipment to ± 5 percent of specified airflow. Return

branch and mains shall be balanced ± 5 percent of specified airflow, exhaust shall be within-10% of design airflow.

C. Differential Space Pressure:

1. Positive Zones: Balance to within 0 to plus10 percent supply air and 0 to minus 10 percent for exhaust and return air.

2. Negative Zones: Balance to within 0 to minus 10 percent supply air and 0 to plus 10 percent exhaust and return air.

D. Hydronic Systems: Balance to within plus or minus 5 percent of design flow.

3.05 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. The TAB contractor shall compare the sum of the CAV/VAV box diffuser readings with the flow indicated by the box's controller prior to calibrating the box's controller. If the two readings agree within +/- 5%, the factory calibration factors shall not be changed. If the readings are not within +/-5%, a documented trouble shooting procedure consisting of checking and resolving the following shall be conducted prior to calibrating the controller to verify: (Refer to Tab 3 - Functional Performance Test Procedures)

1. Box size is per the approved submittal,

2. Manufacturer's gain/flow factor has been correctly entered into the controller,

3. Low pressure duct/connections are tight,

4. Velocity pressure connections at the box inlet and controller are tight and undamaged,

5. Static pressure at the box's inlet exceeds the minimum required, and

6. Box flow measuring device is undamaged.

C. This procedure and results for carrying out steps A-F above are to be retained by the Mechanical Contractor for delivery to the Owner/Design Engineer on request.

D. TAB contractor shall compile an Excel spreadsheet for all terminal boxes, listing each box by its unique identification number, the inlet flow area established by the box manufacturer, the manufacturer's gain factor for the box, final TAB calibrated gain factor for the box if field calibrated, and the ratio of the calibrated gain factor to the manufacturer's gain factor.

E. Require the TAB contractor to measure and include in the report the AHU supply and return fans' flow, rpm, hp, and sensed duct static pressure at the dirty differential pressure drop across both the pre-filter and final filter.

F. The test and balance specification shall require contractor to measure system performance with the pressure drop across filters at the value specified for dirty filters.

G. TAB shall show in their report all the individual velocity measurements from duct or AHU traverses in grid format.

H. The TAB report shall include a static profile of each AHU with the supply fan controlling to the minimum sensed duct static pressure necessary for the system terminal units to achieve maximum cooling design flow simultaneously. This static pressure shall be documented in the report and shall become the duct static pressure set point.

I. The TAB report shall record the VFD speed for all supply and return fan measurements included in the report.

J. Where AHUs share a common outside air duct, relief duct, or louver, specify that the TAB contractor test those AHUs simultaneously in the 100% economizer mode with all boxes at 100% cooling to verify the supply duct static set point and the design supply/return air volume differential are maintained.

K. The TAB contractor shall verify building and space pressure relationships in all modes of operation.

L.

M. 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.

N. 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.

O. Ensure recorded data represents actual measured or observed conditions.

P. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

Q. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

R. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

S. Cut insulation around ductwork and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.

T. Patch and seal insulation, vapor barrier, ductwork, and housings, using materials identical to those removed.

U. Seal ducts and piping and test and repair leaks.

V. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

W. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

X. Check and adjust systems approximately six months after final acceptance and submit report.

Y. 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.

Z. Take all readings at eye level of the indicated value to prevent parallax.

AA. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.

BB. Take measurements in the system where best suited for the task.

CC. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.06 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.

3.07 PRE-TESTING, ADJUSTMENT, AND BALANCING OF EXISTING HYDRONIC 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. Open automatic control valves to full design position to simulate a design day. Close coil bypass valves.

2. Examine HVAC system and equipment installations to verify that existing balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices and balancing valves and fittings are properly installed. Verify that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

3. Remove, clean, and reinsert all strainers.

4. Examine hydronic systems and determine if water has been treated and cleaned.

5. Check pump rotation.

6. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

7. Check air vents at high points of systems and determine if all are operating freely (automatic type) or to bleed air completely (manual type).
8. Set temperature controls so all coils are calling for full flow.
9. Check operation of automatic bypass valves.
10. Measure and record the operating speed, hydronic flow and pressure drop of each pump and hydronic coil.
11. Measure and record the hydronic flow and pressure drop of each piece of HVAC equipment.
12. Measure motor voltage and amperage. Compare the values to motor nameplate information.

C. Mechanical Contractor:

1. Install additional instrumentation and test ports as requested by the testing, adjusting, and balancing contractor to obtain the necessary measurements of the existing system.

3.08 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. Multi-Zone units with Mixing Dampers: Check for motorized damper leakage. Adjust air quantities with mixing dampers set first at design cooling, then at design heating.

X. For variable air volume boxes, set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

Y. On fan powered VAV boxes, adjust air flow switches for proper operation.

Z. 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.

3.09 HYDRONIC SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Open valves to full open position. Close coil bypass valves.

B. Remove and clean all strainers.

C. Check pump rotation.

D. Clean and set automatic fill valves for required system pressure.

E. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

F. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).

G. Set temperature controls so all coils are calling for full flow.

H. Check operation of automatic bypass valves.

I. Check and set operating temperatures of chillers to design requirements.

J. Lubricate all motors and bearings.

K. Adjust water systems to provide required or design quantities.

L. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on correlated flow from temperature and pressure gauges across the heat transfer elements in the system.

M. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

N. Affect system balance with automatic control valves fully open to heat transfer elements.

O. Affect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

P. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

Q. Balance cooling tower water distribution systems to ensure even water flow to each tower cell.

R. Test cooling tower systems for capacity, recording pump flow and head, fan airflow, ambient air wet and dry bulb temperatures at tower inlet and outlet and tower inlet and outlet water temperatures.

S. Record the necessary information for optimizing pump operation as defined on the controls drawings. Give this information to the controls contractor for building automation system programming.

3.10 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.

3.11 STEAM SYSTEM TESTING, ADJUSTMENT, AND BALANCING PROCEDURE

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure reducing valves.

C. Check settings and operation of automatic temperature control valves, self-contained control valves, and pressure reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify operation of each steam trap.

3.12 TESTING FOR SOUND AND VIBRATION

A. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards:

1. ASHRAE: ASHRAE Handbook, HVAC Applications Volume, Chapter “Sound and Vibration Control”, most current edition.

2. NEBB: "Procedural Standards for the Measurement and Assessment of Sound and Vibration."

B. The TAB Contractor shall measure the HVAC background noise level in all the spaces specified in Division 23: Mechanical, Section I: Mechanical General, 1.01F. The sound level shall be measured at the patient head location in patient in patient sleeping and therapy rooms. In all other rooms the sound level is to be measured at the approximate center of the room 48″ above floor level. The TAB report shall document the measure NC level for each space. The TAB report shall also include an NC curve for any space that exceeds the specified NC limit.

C. Other than sound data, failure of an item includes a deviation of more than 10 percent from setpoint. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.

1. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

D. Prepare and submit report of recommendations for correcting any sound or vibration levels that are outside of manufacturer’s tolerances, ASHRAE standards and/or values specified in the contract documents.

END OF SECTION 23 05 93

SECTION 23 07 00
HVAC INSULATION

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

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

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

1. Piping Systems Insulation:
    a. Fiberglass
    b. Cellular Glass
    c. Flexible Elastomeric
    d. Phenolic
2. Ductwork System Insulation:
    a. Fiberglass
3. Equipment Insulation:
    a. Fiberglass
    b. Cellular Glass
    c. Flexible Elastomeric

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

1. Division 23 Section "Hangers & Supports for HVAC Piping & Equipment," for insulation shields and pipe saddles for protecting insulation vapor barrier and materials and methods for piping installations.
2. Division 23 Section “Underground Hydronic and Steam Piping,” for insulation of piping installed below grade.

1.02 QUALITY ASSURANCE

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

B. 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 E 84 (NFPA 255) method.

1.03 SUBMITTALS

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

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

C. Samples: Submit manufacturer's sample of each piping insulation type required, and of each duct and equipment insulation type required. Affix label to sample completely describing product.

PART 2 - PRODUCTS AND MATERIALS

2.01 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. Johns Manville
5. Knauf Insulation
6. K-Flex USA
7. Owens Corning
8. Pittsburgh Corning Corp.
9. Resolco

2.02 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C547, Type I or II, Grade A.

B. Cellular Glass Piping Insulation: ASTM C552, Type II, Class 2.

C.

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

E. Phenolic Piping Insulation: ASTM C1126 Type III

F. Jackets for Piping Insulation: ASTM C1136, Type I.

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.
2. Use all service jacket (ASJ) in equipment rooms. Foam glass concealed above ceilings and within shafts does not need to be covered. Do not use factory pre-applied ASJ on foam glass. The pre-applied jacket prevents application of mastic on the longitudinal and circumferential joints.
3. For hot water, steam and steam condensate piping shall be insulated with molded fiberglass pipe insulation having ASJ finish

G. Jackets for Pipe Insulation Exposed to Weather (ONLY FOAM GLASS MAY BE USED EXTERIOR TO BUILDING): Approved by the jacket manufacturer for use with the specific insulation material that it covers.

1. Rigid aluminum shell and fitting covers 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		
< 12	0.020	0.016
Stucco		

≤ 24	0.024	0.016
Stucco		
≤ 36	0.032	0.020
See Note 1		
> 36	0.040	0.024
See Note 1		

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.

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

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

1. Vapor Barrier Coating: Comply with MIL-PRF-19565C, Type II.

a. Water-Based Mastic: Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E 96 Procedure B. Provide Foster 30-80, Childers CP-38 or equal vapor barrier mastic.

b. Solvent-Based Mastic: Permeance shall be 0.05 perms or less at 35 mils dry per ASTM F 1249.

2. Lagging Adhesive: Comply with MIL-A-3316C, Class 1, Grade A. Provide Foster 30-36, Childers CP-50AHV2 or equal.

3. 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.

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

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

L. High Density Insulation:

1. Calcium Silicate conforming to ASTM C533 and C795.

2. Flexible elastomeric piping insulation conforming to ASTM C534, Type 1.

2.03 DUCTWORK INSULATION MATERIALS

A. Rigid Fiberglass Ductwork Insulation: UL/ULC Classified, meeting ASTM C612, Types IA or IB, with density of 3.0 pounds per cubic foot.

B. Flexible Fiberglass Ductwork Insulation: UL/ULC Classified, meeting ASTM C553, Type II, with density of 1.5 pounds per cubic foot.

C. Jackets for Ductwork Insulation: ASTM C1136, Type I or Type II for ductwork. Protective jackets for ductwork shall be ASTM C921 Type I made of sheet aluminum in accordance with ASTM B 209, 3003 alloy, H-14 temper, minimum 0.032 inch thick with a moisture barrier lining except where the protective jacket is applied over a Type I vapor barrier jacket and with stainless steel draw bands.

D. Ductwork Insulation Accessories: Provide staples, bands, wires, pins with insulation retaining washers, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

E. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

1. Vapor Barrier Coating: Comply with MIL-PRF-19565C, Type II.

a. Water-Based Mastic: Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E 96. Provide Fosters 30-80, Childers CP-38 or equal.

b. Solvent-Based Mastic: Permeance shall be 0.05 perms or less at 35 mils dry per ASTM F 1249.

2. Fiberglass 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.

F. Jackets for Duct Insulation Exposed to Weather: Jackets installed over exterior duct insulation shall be approved by the jacket manufacturer for use with the specific insulation material that it covers. Jackets utilized to cover exterior duct insulation shall include one of the following options:

1. Encase fiberglass insulation with rigid aluminum shell with weather-proof construction. Shell shall be minimum 0.032 inch stucco embossed aluminum with three aluminum attachment bands per section and with aluminum fitting covers.

2.04 EQUIPMENT INSULATION MATERIALS

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

B. Flexible Fiberglass Equipment Insulation: ASTM C553, Types IA and IB

C. Cellular Glass Equipment Insulation: ASTM C552, Type I.

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

E. 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.

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

1. Vapor Barrier Coating: Comply with MIL-PRF-19565C, Type II.. Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E 96 or 0.08 perms at 37 mils dry per ASTM F 1249. Provide Foster 30-80, Childers CP-38 or equal.

2. Lagging Adhesive: Comply with MIL-A-3316C, Class 1, Grade A. Provide Foster 30-36. Childers CP-50AHV2 or equal.

3. Fiberglass Adhesive: Comply with ASTM C916, Type II.

G. 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

3.01 PIPING SYSTEM INSULATION

A. General: Reference Insulation Schedules at the end of this specification for minimum insulation conductivity and thickness requirements.

B. Insulation Omitted: 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;
4. Condensate piping between steam trap and union; and
5. Flexible connections and expansion joints in pipes with fluids above ambient temperatures.

C. Exterior Piping: Insulate all exterior HVAC piping with cellular glassof thickness noted.

D. Sub-Zero Piping (Below 0 degrees F) (-18 degrees C)):

1. Application Requirements: Insulate the following sub-zero HVAC piping systems:
   a. Low temperature refrigerant piping.
2. Insulate each piping system specified above with one of the following types of insulation:
   a. Cellular Glass
   b. Flexible Elastomeric
   c. Phenolic

E. Sub-Freezing Piping (0 to 39 degrees F (-18 to 4 degrees C)):

1. Application Requirements: Insulate the following sub-freezing HVAC piping systems:
   a. Refrigerant suction lines between evaporators and compressors.
   b. Refrigerant liquid lines between the expansion valve and the evaporator coil.
   c. Brine refrigerant piping.
2. Insulate each piping system specified above with one of the following types of insulation:
   a. Cellular Glass
   b. Flexible Elastomeric: Insulation shall be seamless except where piping joints need to be made. Seams at piping joints shall be sealed and taped.
   c. Phenolic

F. Cold Piping (40 degrees F (4.4 degrees C) to ambient):

1. Application Requirements: Insulate the following cold HVAC piping systems:
   a. HVAC chilled water supply and return piping.
   b. HVAC make-up water piping.
   c. Air conditioner condensate drain piping.
   d. Condenser water supply and return piping when used for free cooling.
2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Cellular Glass
b. Flexible Elastomeric
c. Phenolic

G. Warm Temperature Piping (100 degrees to 140 degrees F (38 to 94 degrees C)):
1. Application Requirements: Insulate the following warm HVAC piping systems:
a. HVAC hot water supply and return piping.
b. Refrigerant liquid lines between the condensing unit and evaporator coil.
2. Insulate each piping system specified above with one of the following types of insulation.
a. Fiberglass
b. Phenolic

H. Hot Non-Steam Piping (141 to 200 degrees F (61 to 94 degrees C)):
1. Application Requirements: Insulate the following hot HVAC piping systems.
a. HVAC hot water supply and return piping.
b. Heated fuel piping.
c. Hot gas refrigerant piping.
2. Insulate each piping system specified above with one of the following types of insulation:
a. Fiberglass
b. Cellular Glass
c. Phenolic

I. Hot Steam Piping (up to 250 degrees F (121 degrees C)):
1. Application Requirements: Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi).
a. Steam and condensate piping
2. Insulate each piping system specified above with one of the following types of insulation:
a. Fiberglass
b. Cellular Glass
c. Phenolic

J. Hot Water and Steam Piping (250 to 350 degrees F (122 to 177 degrees C)):
1. Application Requirements: Insulate the following hot HVAC piping (steam piping from 16 to 110 psi, water piping 251 to 350 degrees F (122 to 177 degrees C)):
a. HVAC hot water supply and return piping.
b. Steam and condensate piping.
2. Insulate each piping system specified above with one of the following types of insulation:
a. Fiberglass

b. Phenolic

c. Cellular Glass

3.02 DUCTWORK SYSTEM INSULATION

A. Insulation Omitted: Do not insulate fibrous glass ductwork, or lined ductwork. Refer to Section “Metal Ductwork” for requirements for duct liner material.

B. Application Requirements:

1. Insulate the following ductwork:

a. Outdoor air intake ductwork and plenums between air entrance and fan inlet or HVAC unit inlet.

b. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet.

1) Insulate neck and bells of supply diffusers.

c. HVAC return ductwork between room terminal inlet and return fan inlet, or HVAC unit inlet. Omit insulation on return ductwork located in return air ceiling plenums except insulate all return air ductwork within 10 feet of exterior roof or wall penetrations.

d. HVAC plenums and unit housings not pre-insulated at factory or lined.

e. Exhaust and relief air ductwork and plenums within 10 feet of exterior discharge outlets.

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

a. Rigid Fiberglass: 2” thick, minimum R-8.0. Use 2" thick, minimum R-8 in machine, fan and equipment rooms.

b. Flexible Fiberglass: 3” thick, minimum R-8.0 installed R-value at maximum 25% compression, application limited to concealed locations.

3.03 EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment unless pre-insulated at factory:

a. Refrigeration equipment, including chillers, tanks and pumps.

b. Drip pans under chilled equipment.

c. Chilled water storage tanks.

d. Chilled water expansion tanks, air separators and piping accessories.

e. Chilled water pumps.

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. Cellular Glass: 3" thick for surfaces above 35 degrees F (2 degrees C) and 4-1/2" thick for surfaces 35 degrees F (2 degrees C) and lower.

c. Flexible Elastomeric: 1" thick.

B. Hot Equipment (Above Ambient Temperature):

1. Application Requirements: Insulate the following hot equipment unless pre-insulated at factory:

a. Boilers.

b. Hot water storage tanks.

c. Heat exchangers.

d. Condensate receivers.

e. Hot water expansion tanks.

f. Hot water pumps.

g. Condensate pumps.

h. Fuel oil heaters.

i. Emergency generator silencers.

j. Flash tanks.

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

a. Fiberglass: 2" thick, except 3" thick for low-pressure boilers and steam-jacketed heat exchangers.

b. Flexible Elastomeric: 1" thick. Do not use for equipment operating above 180 degrees F (82 degrees C) or 300F (149C) for high-temperature formula.

3.04 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. Provide high density insulation material under supports or pre-insulated supports for cold piping. 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.

1. Insulation material shall extend a minimum 2 inches past the pipe shield on each side.

G. Butt pipe insulation tightly at insulation joints. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band and coat all taped seams with vapor barrier coating to prevent moisture ingress.

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

1. Insulate pipe elbows using fiberglass inserts with pre-molded PVC parts, preformed fitting insulation, or mitered fittings made from same material and density as adjacent pipe

insulation. Each piece shall be butted tightly against adjoining piece and bonded 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.

2. Insulate tee fittings with fiberglass inserts with pre-molded PVC parts, 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.

3. Insulate valves using fiberglass inserts with pre-molded PVC parts, 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.

4. Insulate strainers using fiberglass inserts with pre-molded PVC parts, 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.

5. Insulate flanges and unions using fiberglass inserts with pre-molded PVC parts or 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.

6. Cover segmented insulated surfaces with a layer of finishing cement and finish with a coating or mastic. Install vapor-barrier coating for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the coating or mastic to a smooth and well-shaped contour.

7. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

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

9. Fittings on foam glass insulation shall be made up of mitered sections of foam glass.

10. Fittings on fiberglass pipe insulation shall be mitered insulation up to 2″ diameter and molded fittings for 2½″ and larger. All indoor fitting insulation shall be covered with a tight fitting PVC jacket.

I. 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.

J. 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.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

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

L. Exterior Piping:

1. Encase piping insulation exposed to weather with one of the following:
   a. Rigid aluminum shell with attachment bands spaced 12 inches on center and directly centered over end joints.
2. Locate longitudinal seams of outer shellat bottom of pipe. Install cladding in strict conformance with cladding manufacturer’s instructions and apply coatings in strict conformance with insulation manufacturer’s instructions. Provide insulation shields so that the piping supports cannot puncture, cut or break the jacket.

3.05 INSTALLATION OF DUCTWORK 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 indented purpose.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage,

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

F. Cold Ductwork in Mechanical Rooms or Other Non-Conditioned Spaces: To prevent condensation from forming on the duct supports, provide one or more of the following:

1. Install thermal break such as rigid board insulation between the support and duct.
2. Wrap support that is in contact with the duct with external duct wrap insulation to prevent condensation. Wrap shall extend a minimum of 12” from point of contact of the support with the duct. Coat all joints, punctures and seams with 4” wide coating of vapor barrier mastic.
3. If a support device similar to unistrut is used, foam fill or stuff tube.

G. Exterior Ductwork: Install ductwork with sufficient slope to ensure that water cannot pond anywhere on the duct. Drainage must be achieved by sloping ductwork – not by varying the

insulation thickness. Locate longitudinal seams of outer shell at bottom of duct. Install cladding in strict conformance with cladding manufacturer's instructions.

H. Protect outdoor insulation from weather by installing outdoor protective weather barrier mastic and reinforcing mesh as recommended by manufacturer or protective jacket as specified. Install protective jacket in accordance with manufacturer's recommendations.

I. 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.

3.06 THE INSULATION IS TO BE SECURED USING OUTWARD CLINCHING STAPLES ON DUCTWORK UP TO 36″ WIDE AND STICK PINS ABOVE 36″ WIDE. SEAL STAPLES AND PINS WITH MASTIC, NOT SELF-SEALED TAPE. 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. Tape all joints using a suitable, matching acrylic adhesive tape; minimum 3" wide.

F. Coat insulated surfaces of calcium silicate 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. Tape all joints using a suitable, matching acrylic adhesive tape; minimum 3" wide.

H. Do not insulate boiler manholes, handholes, 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.

3.07 EXISTING INSULATION REPAIR

A. Repair existing mechanical insulation that is damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

3.08 PROTECTION AND REPLACEMENT

A. Provide all required protection for insulation (installed and uninstalled) throughout the duration of construction to avoid exposure to moisture, deterioration, and physical damage.

B. Replace damaged insulation which cannot be repaired satisfactorily, including insulation with vapor barrier damage and insulation that has been exposed to moisture during shipping, storage, or installation.

C. Dry surfaces prior to installation of new insulation that replaces the damaged or wet insulation.

3.09 PIPE INSULATION SCHEDULES

A. IECC – 2015 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

Fluid Operating Temp. Range (°F) And Usage	Insulation Conductivity Conductivity, Btu·in./(hr·ft²·°F)	Mean Rating Temp., °F.	Nominal Pipe or Tube Size (in.) <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	50	0.5	1.0	1.0	1.0	1.5

Notes:

a. 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.

b. Insulation thicknesses are based on energy efficiency considerations only. Add insulation where safety issues, surface temperature, water vapor permeability, or surface condensation are a concern; or where noted on the drawings.

c. For piping that shall be installed below grade, reference Division 23 section “Underground Hydronic and Steam Piping.”

d. 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.

B. IECC – 2012 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

Fluid Operating Temp. Range (°F) And Usage	Insulation Conductivity Conductivity, Btu·in./(hr·ft²·°F)	Mean Rating Temp., °F.	Nominal Pipe or Tube Size (in.) <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 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.

b. Insulation thicknesses are based on energy efficiency considerations only. Add insulation where safety issues, surface temperature, water vapor permeability, or surface condensation are a concern; or where noted on the drawings.

c. For piping that shall be installed below grade, reference Division 23 section “Underground Hydronic and Steam Piping.”

d. 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.

C. IECC – 2009 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

Fluid	Insulation Conductivity Conductivity, Btu·in./(hr·ft²·°F)	Nominal Pipe or Tube Size (in.) ≤1-1/2	>1-1/2
Steam	≤0.27	1.5	3.0
Hot Water	≤0.27	1.5	2.0
Chilled Water, brine, or refrigerant	≤0.27	1.5	1.5

Notes:

a. For insulation with a thermal conductivity greater than the stated conductivity limit at a mean temperature of 75°F, 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 and pipe size,
4) K = conductivity of alternate material at 75°F (Btu·in./hr·ft²·°F); and
5) k = 0.27 (Btu·in./hr·ft²·°F).

D. IECC – 2006 Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

Fluid	Insulation Conductivity Conductivity, Btu·in./(hr·ft²·°F)	Nominal Pipe or Tube Size (in.) ≤1-1/2	>1-1/2
Steam	≤0.27	1.5	3.0
Hot Water	≤0.27	1.0	2.0
Chilled Water, brine, or refrigerant	≤0.27	1.0	1.5

E. ASHRAE 90.1 – [2013][2010] Requirements, Pipe Insulation

Minimum Pipe Insulation Thickness

Fluid Operating Temp. Range (°F) And Usage	Insulation Conductivity Conductivity, Btu·in./(hr·ft²·°F)	Mean Rating Temp., °F.	Nominal Pipe or Tube Size (in.) <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	0.22–0.28	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	50	0.5	1.0	1.0	1.0	1.5

Notes:

a. 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.

b. Insulation thicknesses are based on energy efficiency considerations only. Add insulation where safety issues, surface temperature, water vapor permeability, or surface condensation are a concern; or where noted on the drawings.

c. For piping that shall be installed below grade, reference Division 23 section “Underground Hydronic and Steam Piping.”

d. 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.

F. ASHRAE 90.1 – 2007 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	2.5	3.0	3.0	4.0	4.0
251°F–350°F	0.29–0.32	200	1.5	2.5	3.0	3.0	3.0
201°F–250°F	0.27–0.30	150	1.5	1.5	2.0	2.0	2.0
141°F–200°F	0.25–0.29	125	1.0	1.0	1.0	1.5	1.5
105°F–140°F	0.22–0.28	100	0.5	0.5	1.0	1.0	1.0
40°F–60°F	0.22–0.28	100	0.5	0.5	1.0	1.0	1.0
<40°F	0.22–0.28	100	0.5	1.0	1.0	1.0	1.5

Notes:

a. 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.

b. Insulation thicknesses are based on energy efficiency considerations only. Add insulation where safety issues, surface temperature, water vapor permeability, or surface condensation are a concern; or where noted on the drawings.

c. For piping that shall be installed below grade, reference Division 23 section “Underground Hydronic and Steam Piping.”

d. 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.

G. California Building Efficiency Standards (Title 24 – Part 6) 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	0.22–0.28	100	1.0	1.5	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	50	1.0	1.5	1.5	1.5	1.5

Notes:

a. 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 lower value of the conductivity range listed in this table for the applicable fluid temperature.

b. Insulation thicknesses are based on energy efficiency considerations only. Add insulation where safety issues, surface temperature, water vapor permeability, or surface condensation are a concern; or where noted on the drawings.

c. For piping that shall be installed below grade, reference Division 23 section “Underground Hydronic and Steam Piping.”

d. 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.

END OF SECTION 23 07 00

SECTION 23 08 00
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 Scope

A. A. Work under this Section is subject to requirements of the Contract Documents including Divisions 00 and 01.

1.2 Description

A. Commissioning is a systematic process of ensuring the HVAC systems perform interactively according to the design intent and Owner's operational needs. Commissioning will encompass and coordinate traditionally separate functions of system documentation, installation checkout, equipment startup, control system calibration and point-to-point checkout, testing and balancing, and functional performance testing. Commissioning is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify systems are in accordance with the plans and specifications.
2. Verify and document proper installation and performance of equipment and systems.
3. Ensure O&M, maintenance training, and commissioning documentation requirements are complete.
4. Provide Owner with functional buildings and/or systems with minimal operational problems at time of move-in.

B. Commissioning does not take away from or reduce responsibility of system designers or installing contractors to provide a finished and fully functioning product.

C. This section shall in no way diminish the responsibility of the Division 23 Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the contract documents. Any requirements outlined in this section are in addition to requirements outlined in Division 23 Specifications.

1.3 Abbreviations

A. The following are common abbreviations used in the Specifications. Definitions are found further in this Section.

Abbreviation	Full Name	Additional Information
A/E	Architect and Design Engineers	The HVAC Engineer
BAS	Building Automation System	
CA	Commissioning Agent	An employee or agent of the GC
CM	Construction Manager	HCA Construction Manager

Abbreviation	Full Name	Additional Information
CT	Commissioning Team	
Cx	Commissioning	
CC	Controls Contractor	
DFM	HCA Director of Facility Management	
EC	Electrical Contractor	
FPT	Functional Performance Test	
GC	General Contractor	
MC	Mechanical Contractor	
OR	Owner's Representative	
PC	Pre-functional Checklist	
TAB	Test, Adjust and Balance	
O&M	Operations & Maintenance	
RFI	Request for Information	

1.4 Related Work

A. Specific commissioning requirements are given in the following sections of these specifications. The following sections apply to work specified in this section.

1. Section 23 08 00 - Commissioning

1.5 Coordination

A. Commissioning Team: Members of the Commissioning Team (CT) will consist of:

1. Commissioning Agent (CA)
2. Owner's Representative(s) (OR)
3. Construction Manager (CM)
4. Architect and Design Engineers (A/E)
5. Mechanical Contractor (MC)
6. Electrical Contractor (EC)
7. Test and Balance Contractor (TAB Contractor)
8. Controls Contractor (CC)
9. Equipment Suppliers and Vendors

B. Management: The CA directs and coordinates commissioning activities. All members of the Commissioning Team shall cooperate to fulfill contracted responsibilities and objectives of the Contract Documents.

C. Kick-off Meeting: Within 90 days of commencement of construction, CA and OR will plan, schedule and conduct a commissioning kick-off meeting. Membership and responsibilities of the commissioning team will be clarified at this meeting. CA will distribute meeting minutes to all parties.

D. Scheduling:

1. CA and OR will work with commissioning team to establish required commissioning activities to incorporate in preliminary commissioning schedule. The CA and GC will integrate commissioning activities into the master construction schedule. Representatives of the commissioning team will address scheduling problems. Necessary notifications are to be made in a timely manner in order to expedite commissioning.
2. The CA and OR will provide initial schedule of primary commissioning events at commissioning kick-off meeting. As construction progresses, more detailed schedules are developed by the CA.

1.6 Definitions

A. Acceptance Phase: Phase of construction after startup and initial checkout when Functional Performance Tests, O&M documentation review and training occur.

B. Approval: Acceptance that a piece of equipment or system has been properly installed and is functioning in tested modes according to the Contract Documents.

C. Architect/Engineer (A/E): Prime consultant (architect) and sub-consultants who comprise the design team, generally HVAC Mechanical Designer/Engineer and Electrical Designer/Engineer.

D. Commissioning Agent (CA): An assigned employee or agent of the GC. CA directs and coordinates day-to-day commissioning activities.

E. Contract Documents: Documents binding on parties involved in construction of this project (drawings, specifications, change orders, amendments, contracts, etc.).

F. Control System: System and components associated with building automation system.

G. Construction Manager (CM): Owner's employee assigned the responsibility of managing the overall project.

H. Deferred Functional Tests: Functional tests performed after substantial completion due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow test from being performed.

I. Deficiency: Condition of a component, piece of equipment or system that is not in compliance with Contract Documents (that is, does not perform properly or is not complying with design intent).

J. Director of Facility Management (DFM): Facility employee responsible for the maintenance of the Physical Plant.

K. Factory Testing: Testing of equipment on-site or at factory, by factory personnel.

L. Functional Performance Test Procedures: Commissioning protocols and detailed test procedures and instructions that fully describe the steps required to determine if the system is performing and functioning properly. These procedures are written by the A/E and shall be used to document Functional Performance Tests. They shall be included in the Project Manual.

M. Functional Performance Test (FPT): A demonstration of the dynamic function and operation of equipment and systems. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with contract documents. The test results are both manually recorded on the FPT Procedure and with trending data using the BAS. Functional Performance Tests are executed after pre-functional checklists and startups are complete.

N. General Contractor: Contracted directly to Owner. Sub-contractors report to the General Contractor.

O. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

P. Manual Test: Using hand-held instruments, immediate control system readouts, or direct observation to verify performance (contrary to analyzing monitored data taken over time to make "observation").

Q. Monitoring: Recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or trending capabilities of control systems.

R. Non-Compliance: See Deficiency.

S. Non-Conformance: See Deficiency.

T. Overridden Value: Writing over a sensor value in the control system to see response of a system (e.g., changing outside air temperature value from 50°F to 75°F to verify economizer operation). See also "Simulated Signal".

U. Owner's Representative (OR) – An employee of the Owner or person contracted with the Owner to provide Cx Verification Services. The responsibility of the OR is to assist the Cx Team in understanding the Cx

requirements of the project, monitor the Cx progress through site visits and Cx Team Meetings, review the completed Cx Pre-Functional Performance Checklists and Functional Performance Test for completeness, perform Cx verification testing as appropriate to determine that the Cx requirements of the project have been successfully completed.

V. Owner Verification: A repeat of the FPTs in the presence of the OR and A/E. The OR will determine if only selected or all FPTs will be repeated based on his inspection and review of the Cx documentation submitted by the CA prior to this visit. Typically the length of this visit is less than 3 days. On phased projects, phased commissioning may be required.

W. Phased Commissioning: Commissioning completed in phases (by floors, for example) due to size of structure or other scheduling issues.

X. Pre-functional Checklist (PC): 1) A list of static inspections and elementary component tests that verify proper installation of equipment (e.g., belt tension, oil levels, labels affixed, gages in place, sensors calibrated, etc.). 2) Pre-functional Checklists may also include startup tests that prepare equipment and system for functional operation. 3) A summary of specified documentation is presented in checklist format. The A/E shall include the PCs in the Project manual.

Y. Seasonal Performance Tests: Functional Performance Tests or parts thereof that are deferred until system(s) ambient conditions are closer to design conditions in order to verify proper system operation.

Z. Simulated Condition: Condition created for testing component or system (e.g., applying heat to space temperature sensor to monitor response of VAV box).

AA. Simulated Signal: Disconnecting a sensor and using a signal generator or a software value to simulate an input value to the BAS.

BB. Specifications: Construction specifications of Contract Documents.

CC. Startup: The activities where systems or equipment are initially tested and operated. Startup is completed prior to functional testing.

DD. Sub-contractor: Contractors of GC, and their sub-contractors, who provide and install building components and systems.

EE. Test Procedures: Step-by-step processes, which must be executed to fulfill test requirements.

FF. Test Requirements: Requirements specifying what modes and functions, etc. will be tested.

GG. Trending: Recording of parameters (flow, temperature, pressure, status, etc.) during system operation using the BAS.

HH. Vendor: Supplier of equipment.

II. Warranty Period: Warranty period for entire project, including equipment components.

1.7 Submittals

A. CA shall provide the OR and A/E an "as-built" controls submittal 5 working days prior to the scheduled Owner's Verification visit. The submittal shall include the full sequences of operation that describe the actual controls programming.

1.8 Start-Up

A. Sub-contractor responsible for purchase, installation and startup of equipment shall perform the manufacturer's detailed startup and checkout procedures in addition to the PCs.

B. GC/Sub-contractor shall compile documentation and recording forms for all testing and start-up required by Division 22, 23, and 26 specifications (e.g. duct pressure testing, duct cleaning, pipe pressure testing, piping flushing and cleaning plans, electrical testing, etc.). Testing documentation shall include:

1. Completed test forms
2. Completed Start-up forms
3. Equipment Maintenance Log

PART 2 - PRODUCTS

2.1 Test Equipment

A. Division sub-contractors shall provide all specialized tools, test equipment and instruments required to execute startup, checkout and functional performance testing of equipment under their contract.

B. Test equipment shall be of sufficient quality and accuracy to test and/or measure system performance with tolerances specified. A testing laboratory shall have calibrated test equipment within the previous 12 months. Calibration shall be NIST traceable. Equipment shall be calibrated according to manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 Commissioning Overview

The following provides a brief overview of typical commissioning tasks during construction and the general order in which they occur:

A. Commissioning during construction begins with a kick-off meeting conducted by CA and OR where membership of commissioning team is established, responsibilities reviewed, and the Cx scope and procedures are reviewed. A preliminary commissioning schedule is distributed for review.

B. CA schedules subsequent meetings as necessary to plan, coordinate and schedule commissioning activities. Deficiencies and problem resolution will also be discussed at these meetings.

C. CA develops, with cooperation of sub-contractor/vendor, detailed training plan. The CA schedules training activities with the facility's staff.

D. CA supervises the execution of the PCs completed by the subcontractors. PCs shall be completed for a piece of equipment prior to scheduling startup.

E. CA will witness startup of selected equipment. Startup Reports will be kept in the Start-Up Binder for review.

F. Sub-contractors complete testing (e.g. duct and piping pressure testing, piping flushing, etc.) as required by Division 1, 22, and 23 specifications. Sub-contractors compile copies of completed testing documentation in the Start-Up Binder for CA and OR review.

G. Sub-contractors perform start-up and initial checkout Sub-contractors assemble completed Start-Up Plan documentation and submit to CA for verification of completion of start-up activities prior to functional performance tests.

H. CA assembles the Cx team for a step by step review of the FPT procedures in advance of the execution of the first FPT. The A/E shall lead this review and immediately update any FPT that requires changes.

I. Functional testing is completed after TAB is completed.

J. A/E shall be present to assist in the execution of the first FPT. The CA shall coordinate the schedule for this test to coincide with the A/E's scheduled trip to attend an Owner-Architect-Contractor meeting.

K. Functional Performance Tests are executed by sub-contractors, under supervision of and documented by CA.

L. CA is responsible for having the completed FPT procedures, the specified trending data, the final T&B report, and the "as-built" control submittal to the OR and A/E not less than 5 working days prior to the scheduled Owner's Verification visit.

M. All the FPTs must be completed and the Owner's Verification must occur prior to occupancy unless otherwise directed by the CM. (Owner Verification may be waived on some phases of a phased project; however, the FPTs and controls submittal must be submitted to the OR prior to occupancy.)

N. Items of non-compliance in material, installation or setup will be corrected at sub-contractor expense and system shall be retested.

3.2 Systems To Be Commissioned

A. Mechanical:

1. Air Handling systems including air handlers, air terminal boxes, energy recovery systems, exhaust fans and ancillary equipment
2. Chilled water system including chillers, cooling towers, pumps, and ancillary equipment
3. Steam system and components serving HVAC system
4. Heating Hot Water system including boilers, convertors, pumps and ancillary equipment
5. Building Automation System

B. Plumbing:

1. Domestic Hot Water Recirculation System

C. Electrical:

1. Emergency Generator

3.3 Responsibilities

Responsibilities of commissioning team members are:

A. Architect/Engineer (A/E):

1. Develop detailed PCs.
2. Develop detailed project specific FPT procedures.
3. Review FPTs in detail with the Cx Team.
4. Witnesses first run of first FPT.
5. Review all Cx documentation, including TAB reports, and provide written comments to the OR and CA within 5 days of receipt.

B. Commissioning Agent (CA):

1. Coordinate and direct commissioning activities in a logical, sequential and efficient manner.
2. Schedule and chair Cx kick-off meeting and issue minutes.
3. Incorporate commissioning activities into master construction schedule.
4. Schedule and chair all commissioning team meetings and issue minutes.
5. Provide progress reports of commissioning status.
6. Periodically update commissioning schedule.
7. Supervise completion of Pre-functional Checklists and supporting documentation to verify systems readiness for Functional Performance Testing.
8. Supervise Functional Performance Tests. Document test results and recommend system for acceptance.
9. Review completed TAB reports.
10. Develop, with cooperation of sub-contractor/vendor and DFM, a detailed training plan.
11. Schedule and oversee training sessions.
12. Prepare final Commissioning Turnover Documentation.

13. Facilitate cooperation of sub-contractors in commissioning work.
14. Forward completed TAB report, as-built controls submittal, FPT procedure, and trend data to OR and A/E and at least 5 working days prior to scheduled Owner Verification visit.
15. Identify, track and coordinate resolution of non-compliance and deficiencies identified by commissioning team. Maintain records of all issues submitted by commissioning team.
16. Coordinate sub-contractor/vendor participation in training sessions. Provide workspace or conference room as needed. Ensure attendance at training is documented.
17. Schedule, coordinate and assist CT in seasonal or deferred testing.

C. Sub-contractors/Vendors:

1. Review PCs and Functional Performance Test procedures.
2. Attend commissioning kick-off meeting and other commissioning team meetings.
3. Ensure installation work is complete, is in compliance with Contract Documents and is ready for Functional Performance Testing.
4. Execute Pre-functional Checklists and submit in electronic format with supporting documentation to CA and OR prior to startup of equipment.
5. Execute all required equipment and systems testing as required by project specifications (e.g. duct pressure testing, piping pressure testing, piping flushing, etc.). Provide schedule of testing activities to CA prior to start of any testing so that CA may witness a sampling of the testing as required. Submit completed testing documentation in final executed Start-Up binder to CA and OR for review prior to start of functional testing.
6. Execute all periodic maintenance required on started equipment from initial start-up of equipment to final acceptance by Owner to prevent equipment warranties from being voided. Document execution of periodic maintenance by signing and dating maintenance logs for each item of equipment.
7. Execute Functional Performance Tests as described in contract documents.
8. Provide certified and calibrated instrumentation required to take measurements of system and equipment performance during Functional Performance Testing.
9. Assist CA with developing a comprehensive commissioning schedule.

10. Execute seasonal or deferred Functional Performance Testing.
11. Make necessary amendments to O&M manuals and as-built drawings/submittals for applicable issues identified in the Cx process.
12. Support the testing that occurs during the Owner's Verification visits.

D. Controls Contractor (CC):

1. Attend commissioning kick-off meeting and other commissioning team meetings.
2. Completely install and thoroughly inspect startup, test, adjust, calibrate and document systems and equipment under BAS Contract.
3. Provide laptop computer, software and training to accommodate TAB Contractor in system balancing.
4. Maintain database of control parameters submitted by TAB Contractor subsequent to field adjustments and measurements.
5. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during Functional Performance Testing and Owner's Verification.
6. Provide instrumentation, computer, software and communication resources necessary to demonstrate total operation of building systems during Functional Performance Testing and Owner's Verification of control system equipment.
7. Maintain comprehensive system calibration and checkout records. Submit records to CA upon request.
8. Submit executed copies of the commissioning functional tests (signed and dated by the control Sub-contractor technician directly responsible for verification of the control sequence or system operation) prior to Owner's Verification(to show that the control Sub-contractor has actually tested and verified each sequence prior to CA witnessing the functional testing).
9. Setup trend logs as requested by CA to substantiate proper systems operation.
10. Prepare the required trending information and submit to the CA.
11. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during Opposed Season Functional Performance Testing.

E. Test, Adjust and Balance (TAB) Contractor:

1. Attend commissioning kick-off meeting and other commissioning team meetings.
2. Complete test and balance procedures prior to functional performance testing.
3. Cooperate with CC with execution of required work.
4. Submit copy of final TAB report to CA for review prior to Owner's verification visit.
5. Rebalance deficient areas identified during commissioning.
6. Provide on-site technician, as necessary, skilled in TAB procedures to provide limited system TAB readings during Functional Performance Testing and Owner's Verification.
7. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during Opposed Season Functional Performance Testing.

3.4 Commissioning Team Meetings

A. Commissioning team meetings will be held periodically as determined by CA and OR with frequency increasing as construction advances and systems become operational. Attendance is mandatory. CA will record minutes and attendance. CA will chair Commissioning Team Meetings.

B. Discussions held in Commissioning Team Meetings shall include, but not be limited to system/equipment startup, progress, scheduling, testing, documentation, deficiencies and problem resolution.

3.5 Reporting

A. CA will at OAC meetings provide regular status reports to CM and A/E.

B. CA will regularly communicate with members of commissioning team, keeping them apprised of commissioning progress.

C. CA shall submit non-compliance and deficiency reports to the CM.

3.6 Pre-Functional Checklists

A. The objective of the Pre-Functional Checklist is to verify and document that the equipment/systems are provided and installed according to documented design intent and Contract Documents.

B. Pre-functional checklists are provided by the A/E and executed as the work is completed in phases by the installing Sub-contractors. The project specific Pre-functional checklists are included at the end of this section by the A/E. GC and Sub-contractors shall review final construction documentation for

applicable details and specifications related to equipment to be commissioned in order to fully ascertain all of the pre-functional checklist requirements.

C. The contractors will execute the pre-functional checklists in phases as work is completed such as setting equipment, piping equipment, insulating it, making up electrical connections, etc. The purpose is to execute the commissioning process and complete the checklists as the work is being completed and not to wait until the end of the installation to complete the checklists.

D. The Mechanical Contractor's field foreman shall inspect each piece of installed HVAC equipment using the appropriate Pre-functional Checklist. He shall initial and date each item when it passes inspection and re-inspect until all items pass.

E. When all items have successfully passed inspection the Mechanical Contractor's superintendent and the General Contractor's project manager shall separately inspect, sign and date the checklists to verify that the installation is complete.

F. The GC will maintain a single "master" hard copy of the PFC checklists executed by the Sub-contractors on-site for CT review during periodic site visits.

3.7 Startup And Initial Checkout

A. CA shall schedule equipment startup after the PCs are executed and documented by Sub-contractor. Startup shall not occur until after the CA and sub-contractors have reviewed the completed PCs.

B. Sub-contractor to prepare an overall schedule of testing and start-up activities in advance and forward to OR so that OR can witness start-up activities as required

C. OR reserves the right to witness any startup or equipment testing. DFM shall be contacted and invited to witness all equipment startup.

D. CA shall provide OR with signed and dated copy of completed startup and pre-functional checklists. Only individuals having direct knowledge that a line item task was actually performed will initial or check that item off.

E. CA shall clearly list outstanding items or initial startup and pre-functional procedures not completed successfully.

F. CA shall review deficiency reports to determine if outstanding items prevent scheduling of Functional Performance Testing.

3.8 Functional Performance Testing

A. Objectives and Scope:

1. The objective of Functional Performance Testing is to demonstrate each system is operating according to documented design intent and Contract Documents. Functional Performance Testing facilitates bringing systems from a state of substantial completion to full dynamic operation. Additionally, during Functional Performance Testing, areas of deficient performance are identified and corrected, improving operation and functioning of systems.
2. Each system shall be operated through all modes of operation where there is a specified system response. Verifying each sequence in the sequences of operation is required.

B. Development of Test Procedures:

1. The purpose of any given specific test is to verify and document compliance with stated criteria of acceptance given on test form. A/E shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Prior to execution, the CA will review the FPT procedures with the A/E and Cx Team (i.e. answering questions about equipment, operation, sequences, etc.). CA shall provide a copy of test procedures to Sub-contractor. Sub-contractor will review tests for feasibility, safety and equipment warranty protection. CA shall also submit tests to Owner, CM and A/E and other commissioning team members for review.
2. Examples of test procedure forms to be developed by the A/E are included herein.

C. Coordination and Scheduling:

1. CA will conduct a step by step table top review of the FPT procedures with the CT weeks in advance of the first FPT.
2. CA shall witness and document functional testing of equipment and systems. Sub-contractor shall execute tests under direction of CA.
3. Functional Performance Testing is conducted after system operation and checkout is satisfactorily completed. Air balancing and water balancing is to be completed and debugged before functional testing of air-related or water-related equipment or systems.
4. CA will schedule Owner’s Verification visit with the OR and A/E after completion of functional performance test procedures by the CA.
5. CA will transmit the completed FPT procedures, associated trend data, TAB report, and “as-built” control submittal to the OR and A/E on a schedule that will give them five working days to review this information prior to the scheduled Owner’s Verification visit.

3.9 Documentation, Non-Conformance And Approval Of Tests

A. Documentation:

1. CA will witness and document the results of the FPTs using specific Functional Performance Test procedures developed for that purpose. CA will include filled out FPTs in Commissioning Turnover Package.

B. Non-Conformance:

1. CA will record results of functional performance testing. Deficiency or non-conformance issues will be noted and reported to A/E and OR on notes section of the FPT procedure.
2. Corrections of minor deficiencies identified may be made during tests at discretion of CA. In such cases, deficiency and resolution will be documented on FPT form.
3. Every effort will be made to expedite testing and minimize unnecessary delays, while not compromising integrity of tests. CA shall not overlook deficient work or loosen acceptance criteria to satisfy scheduling or cost issues unless directed to do so by the OR.
4. Deficiencies are handled in the following manner:
    a. When there is no dispute on deficiency and Sub-contractor accepts responsibility for remedial action:
        i. CA documents deficiency.
        ii. CA reschedules test with Sub-contractor.
    b. When there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
        i. CA documents deficiency and the sub-contractor’s response and they go on to another test or sequence.
        ii. CA facilitates resolution of deficiency. Other parties are brought into discussions as needed. Final interpretive authority is with A/E. Final acceptance authority is with the OR.
        iii. CA documents the resolution.

C. Approval:

1. CA notes each satisfactorily demonstrated function on test form. CA, A/E and OR provide formal approval of FPT. CA recommends acceptance of each test to A/E and OR. The OR maintains a Cx Issues Log that documents the issues/problems that arise during Cx Verification. The OR and A/E work together to update the log until all the issues are resolved to the satisfaction of the OR. The OR notifies

the CM when the Cx Issues are resolved to the extent that occupancy by the Owner can occur.

3.10 Commissioning Documentation

A. Commissioning Turnover Package

1. CA is responsible to compile and organize commissioning records. CA shall deliver Cx records to the OR in Commissioning Binders. Turnover Package to include the following:
    a. "As-built" controls submittal
    b. Pre-functional Checklists
    c. Start-Up Binder with completed testing and start-up reports
    d. Completed Functional Performance Test records
    e. Trend data
    f. A list of deficiencies referenced to a specific FPT section
    g. Final TAB Report

3.11 Training Of Owner Personnel

A. Sub-contractors will provide complete training in startup, operation and maintenance of all equipment under contract.

B. CA will be responsible for overseeing and approving content and adequacy of Facility Staff training.

C. Sub-contractor responsible for training will submit a written training plan to CA for review and approval prior to training. Plan will cover the following elements:

1. Equipment (included in training)
2. Intended audience
3. Location of training
4. Objectives
5. Subjects covered
6. Duration of training on each subject
7. Instructor for each subject
8. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
9. Instructors and qualifications

D. CA coordinates and schedules training with CM, DFM and Sub-contractors. CA develops criteria to determine training satisfactorily completed. CA schedules training sessions with appropriate personnel.

E. CA will provide videotaping of training sessions as required.

3.12 Deferred Testing

A. Deferred Seasonal Testing:

1. During warranty period, seasonal testing (tests delayed until weather conditions are closer to system's design) will be completed as part of this contract. CA will coordinate this activity. Tests will be executed, documented and deficiencies corrected by appropriate contractor(s), with DFM, OR and CA witnessing. CA will incorporate final updates to Commissioning Turnover Package as necessary.

B. Unforeseen Deferred Tests:

1. Any check or test not completed due to building structure, required occupancy condition, or other deficiency, may be delayed upon approval of OR. These tests will be rescheduled as soon as possible.

3.13 Functional Performance Tests And Test Procedures

A. AHU Functional Performance Test – The AHU FPT is to be conducted after the hydronic water balance and air side T&B for the spaces served by the AHU are complete. Portions of this FPT also require that the chilled water and heating water systems operate to produce chilled water and heating water at design temperatures. The AHU FPT requires a 24 hour trend at 3 minute intervals of AHU and chilled water system parameters listed in the FPT procedure. The trending should be scheduled to ensure that fire alarm tests or other activities do not shut down the AHU or hydronic systems during the 24 hour period.

   In the Functional Performance Tests Section (Tab 3) there is an example of AHU FPT (including templates for calculating and displaying the trend data) for the AHU sequence of operation contained in this document (see BAS AHU with and without Preheat Coil Schematic and Sequence of Operation Sections, Tabs 8 and 9). The design consultant is responsible for including in this section of the Project Manual a comprehensive, accurate, and clearly written AHU FPT that is specific to the sequence of operation specified.

B. Air Terminal Unit Functional Performance Tests – Two tests are performed on the Air Terminal Units: a Heating Mode Test and a Cooling Mode Test. Completion of the AHU FPT is a prerequisite to performing these tests. The VAV/CAV Air Terminal Unit Heating and Cooling tests are to be conducted after the hydronic water balance and air side T&B for the terminal units and the AHUs serving these units are completed. These FPTs also require that

the chilled water and heating water systems produce design chilled water and heating water temperatures of typically 42°F and 140°F, respectively, continuously throughout the tests. Coordinate with other trades to insure that the chilled water, heating water, and AHUs involved will operate without interference throughout the duration of the tests, approximately 5 hours for each test. An effort should be made to keep all doors separating the terminal boxes' zones closed during these tests. The Air Terminal Unit FPT can be conducted simultaneously for all the terminal units in the project or selected terminal units may be tested separately from others provided the chilled water system, heating hot water system, and the AHU serving the units meet the prerequisites for conducting the test.

The Heating Mode test is to be performed prior to the Cooling Mode test. The space thermostats involved in the Heating Mode test are to be set at 72°F at least 5 hours immediately prior to beginning the Heating Mode test. This is done to establish steady state temperature conditions prior to raising the space thermostats to a set point of 76°F.

When the building has been given time to stabilize at 72°F begin trending the required parameters. Trend each data point every 3 minutes.

Thirty minutes after beginning the trending of parameters globally change the thermostat set point of the boxes being tested to 76°F. Continue trending for another 5 hours. This completes the Heating Mode Test. The information requested on the Heating Mode Test form (see Functional Performance Test Procedures Section, Tab 3) is only supplied for terminal boxes that do not meet the test criteria specified at the bottom of the form.

The Cooling Mode Test should immediately follow the Heating Mode Test. Globally set the thermostat set point of the boxes being tested to 68°F and continue trending the same parameters for 4½ hours.

If the Cooling Mode Test does not immediately follow the Heating Mode Test, 5 hours prior to starting the Cooling Mode Test adjust the thermostat set point for the terminal units being tested to 74°F. After the 5 hour stabilization period, begin trending the parameters specified in the test form. Thirty minutes after beginning the trending, globally change the thermostat set point of the terminal units being tested to 69°F. Continue trending for another 5 hours.

The trend data is to be presented as tabular data in an Excel workbook. The data for each terminal unit is to be contained in separate work sheets using

the unique terminal unit designation as the name for each sheet. The columns of each work sheet are to be ordered from left to right as follows:

Date and time in ascending order, zone thermostat set point, cooling set point, heating set point, actual zone temperature, terminal unit reheat coil discharge air temperature, reheat valve commanded position, actual cfm, heating cfm set point, cooling cfm set point, commanded damper position, AHU discharge air temperature, AHU static pressure, and heating hot water supply temperature. Shade data of the Heating Mode Test red and the Cooling Mode Test data blue.

The system trend data, AHU discharge air temperature, AHU static pressure, chilled water valve control position, building chilled water supply temperature, building heating hot water supply temperature, and outside air temperature are to be combined in a separate worksheet for each AHU.

Heating Mode and Cooling Mode test forms and templates for calculating and displaying the trend data are included in the Functional Performance Tests Section (Tab 3). These sheets are to be completed for the terminal units that fail the initial FPT or any subsequent FPT.

C. Chilled Water System Functional Performance Test – The Chilled Water System FPT is conducted after chiller startup, hydronic TAB, and the AHU chilled water control valves are under automatic control. This FPT must test or demonstrate: user change of the order in which the chillers are staged; automatic start of the lead chiller; automatic start of the lag chillers in sequence; automatic de-staging of the lag chillers in sequence; automatic staging and control of pumps and pump speeds; the ability of the system to maintain minimum chiller flow; calibration of the chilled water system sensors.

   In the Function Performance Tests Section (Tab 3) there is an example of a Primary/Secondary Chilled Water System FPT. The design consultant is responsible for including in this section of the Project Manual a comprehensive, accurate, and clearly written Chilled Water System FPT that is specific to the sequence of operation specified.

D. BAS/ESC connectivity Functional Performance Test – Coordinate with HCA corporate FacilitiGroup Energy Service center to verify full BAS communication between the facility and ESC.

3.14 Pre-Functional Checklists

***Note to Specifying Engineer: Include PFT Checklists in the Project Manual ***
See Appendix A-2: Pre-Functional Checklists.

3.15 Functional Performance Test Procedures

***Note to Specifying Engineer: Include PFT Checklists in the Project Manual ***
See Appendix A-3: Functional Checklists.

END OF SECTION 23 08 00

SAMPLE CHECKLISTS

SECTION 23 09 13
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Control panels.

B.

C. Control valves.

D. Control dampers.

E. Operators.

F. Flow measuring apparatus.

G. Humidistats.

H. Input/Output sensors and transmitters.

I. Output control devices.

J. Power Supplies.

K. Room pressure controller.

1.02 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. Cv: Design Valve Flow Coefficient.

D. DDC: Direct Digital Control.

E. EPDM: Ethylene Propylene Diene Monomer.

F. High voltage: 50 volts or higher.

G. Low voltage: Below 50 volts.

H. PTFE: Polytetrafluoroethylene.

I. TEFZEL: A modified ETFE (ethylene tetrafluoroethylene) fluoroplastic.

1.03 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. Installation of immersion wells.
2. Installation of flow switches.
3. Installation of automatic control valves.
4. Installation of pressure tappings and associated shut-off cocks.
5. Coordinate conduit and wall box rough-in, power wiring and magnetic starter requirements for controls and mechanical equipment with Division 26.

1.04 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 valves and actuators, including the following:
1. Tag.
2. Quantity.
3. Model number.
4. Equipment served.
5. Flow at project design conditions.
6. Selected valve flow coefficient (Cv). For butterfly valves, submit the corresponding valve position at which the Cv is calculated.
7. Pressure differential drop across valve at project design flow conditions and selected Cv.
8. Maximum close-off pressure.
9. Valve Configuration (2-way/3-way).
10. Valve Normal Position and Fail Position (e.g., NO/FO; normally open/fail open).
11. Valve Size.
12. Line Size.
13. Valve Type.
14. Actuator Signal Type (Open/Close, Modulating 0-10 Vdc, 2-10 Vdc, 4-20 mA, etc.)
15. Torque required to close valve at pump shutoff head.
16. 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.

1.05 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.

1.06 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

2.01 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.

2.02 CONTROL VALVES

A. General:

1. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. Each valve shall be equipped with proper packing to ensure there will be no leakage at the valve stem.
2. Pressure Ratings:
   a. Valve body and packing rated to withstand the system static head plus the maximum pump head and the maximum temperature of the control medium (i.e. chilled water, steam, hot water, etc.).
      1) Minimum pressure class 150 psig.
   b. Two-way modulating valves and their operators shall have close-off pressure ratings exceeding the dead-head condition of the pump in the system it serves.
   c. Two-way modulating valves with equal percentage flow characteristics and their operators shall be rated to safely operate within a differential pressure range between 2 and 50 psi across the valve without cavitating.
3. Sizing:
   a. Hydronic Systems:
      1) Two-Position: Line size or sized using a pressure differential of 1 psi. Size butterfly valves using the 90 degree flow coefficient (Cv).
      2) Modulating: Select valves with an appropriate flow coefficient (Cv) to achieve a minimum design valve authority of 0.5 relative to the total pressure drop of the piping branch the valve controls. Calculate Cv based on the larger of the following:

a) 5-psig pressure drop at the design flow rate specified in the Schedules.
b) Twice the equipment design pressure drop as specified in the Schedules unless otherwise noted:
c) Valve shall not be less than 1/2 Inch in size.
d) Size butterfly valves using the 60 degree of full open flow coefficient (Cv).

4. Flow Characteristics:
   a. Hydronic Service:
      1) Two-way valves: Equal percentage characteristic.
      2) Three-way valves: Linear characteristic.
      3) Chiller isolation valves: Linear characteristic.
   b. Steam Service: Linear flow characteristics.
5. End Connections:
   a. Reference the Control Valve Schedule in Part 3 for allowable end connections by pipe material.
   b. Carbon steel and stainless steel valves shall comply with ASME B16.34.
   c. Comply with ASME B16.10 for face-to-face and end-to-end dimensions.
   d. Threads:
      1) Comply with ASME B1.20.1.
      2) Comply with ASME B16.4 for cast iron.
      3) Comply with ASME B16.15 for cast copper alloys, including bronze and brass.
   e. Flanges:
      1) Comply with ASME B16.5 for steel.
      2) Comply with ASME B16.1 for cast iron
      3) Comply with ASME B16.24 for cast copper alloys, including bronze and brass.
   f. Grooved Fittings:
      1) Water services to 230 deg F and 250 psig.

B. Globe Pattern:
   1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size and end connection by application.
   2. Construction:
      a. Up to 2 inches: Class 150, ASTM B62 bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.
         1) Bronze body and bonnet shall conform to ASTM B62 up to pressure class 150. Conform to ASTM B61 for pressure class 200 and higher.
      b. Over 2 Inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
         1) Iron body and bonnet shall conform to ASTM A126, class B.
      c. Bonnet:
         1) Bronze body, Class 125: Threaded type.
         2) Bronze body, Class 150 or higher: Union type.
         3) Iron body: Bolted type.
      d. Disc Material:
         1) PTFE.
         2) Stainless steel.

e. Stem: Outside screw and yoke. Include extension for insulation.
f. Two-piece brass packing gland assembly, non-asbestos composition packing.

3. Rangeability: Minimum 50:1.
4. Leakage:
   a. Up to 1-1/4 Inch: Minimum ANSI Class III per ANSI/FCI 70-2.
   b. 1-1/2 Inch and Larger: Minimum ANSI Class IV per ANSI/FCI 70-2.
5. Design and Testing:
   a. MSS SP-80 for bronze.
   b. MSS SP-85 for cast iron.

C. Ball Pattern:
1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size by application.
2. Construction:
   a. Body:
      1) Bronze conforming to ASTM B61, B62, and B584.
      2) Forged brass with or without nickel plating conforming to ASTM B283.
      3) Cast carbon conforming to ASTM A216.
      4) Cast iron according to ASTM A126.
      5) Stainless steel conforming to ASTM A351.
   b. Up to 2 inches: Two-piece construction
   c. Stainless steel, blowout proof stem. Include extension for insulation.
   d. Replaceable PTFE seats and EPDM O-ring or PTFE packing seals.
3. Ball: Full port with characterized insert comprised of the following material:
   a. Stainless steel.
4. Rangeability: Minimum 50:1.
5. Leakage: Minimum ANSI Class IV per ANSI/FCI 70-2.
6. Design and Testing:
   a. MSS SP-72 for flanged ends.
   b. MSS SP-110 for threaded and grooved ends.

D. Butterfly Pattern:
1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size by application.
2. Construction:
   a. Body: Lug ends suitable for connecting to ASME B16.5 flanges, or grooved ends.
      1) Cast iron according to ASTM A126.
      2) Ductile iron according to ASTM A536.
      3) Cast steel according to ASTM A216.
   b. Disc:
      1) Aluminum bronze.
      2) Stainless steel.
      3) One-piece nylon coated ductile iron disc. Nylon coated discs are not allowed for open loop condenser water systems.
   c. Stem: 416 Stainless steel. Include extension for insulation.
   d. Replaceable PTFE or EPDM seats and seals.

3. Rangeability: Minimum 20:1.
4. Leakage: Minimum ANSI Class IV, per ANSI/FCI 70-2.
5. Design and Testing: MSS SP-67 for Class 150 and MSS SP-68 for pressure classes above 150.

E. Manufacturers:
1. Belimo.
2. Bray.
3. Danfoss.
4. Fisher Controls.
5. Griswold Controls.
6. Honeywell.
7. Johnson Controls, Inc.
8. Kele.
9. Schneider Electric.
10. Siemens.
11. Victaulic (Tour & Andersson).

2.03 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.
c. Fire/smoke dampers shall have fire resistance of 1-1/2 or 3 hours in accordance with UL 555 as required for the rated assembly that damper is installed.
1) Fire/smoke damper shall have elevated temperature rating of [250 F][350 F] to remain open during smoke control operation.
d. Fire/smoke and smoke dampers shall be rated for Leakage Class I in accordance with UL555S and shall be rated for dual direction airflow.

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.

N. Extended Warranty: Control dampers utilized in an economizer assembly shall be covered with minimum 5 year manufacturer warranty, certified to operate through 60,000 damper opening and closing cycles, and certified to meet leakage requirements specified above.

2.04 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. Position Feedback:
   a. Where indicated on the controls drawings, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
   b. Where indicated on the controls drawings, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
   c. Actuator shall contain position indicator and graduated scale indicating open and closed travel limits.
8. 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.
9. 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.

10. Temperature and Humidity:
    a. Temperature: Suitable for operating temperature range encountered by application.
    b. Humidity: Suitable for humidity range encountered by application, non-condensing.
11. 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.
12. 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. Valve Operators
1. Sizing: Select operator with sufficient torque capacity to operate the valve under all conditions and to guarantee tight shut-off of as specified against system pressure encountered.
    a. Operators for Hydronic Control Valves: Capable of closing valve against system pump dead head.
2. Fail Positions:
    a. Spring return to normal position as indicated on freeze, fire, temperature, or loss of power protection.
        1) Pre-heat coil, normally open.
        2) Humidifier, normally closed.
        3) Other devices needing fail safe operation to account for freeze protection, power failure, overheating or moisture damage, reference control drawing points list for normal position.
    b. Operator shall fail in place for all other applications not listed under spring return.

D. Manufacturers:
1. Damper Operators:
    a. Belimo.

b. Honeywell.
c. Johnson Controls.
d. Schneider Electric (Invensys).
e. Siemens.

2. Valve Operators:
a. Belimo.
b. Bray.
c. Danfoss.
d. Fisher Controls.
e. Honeywell.
f. Johnson Controls.
g. Schneider Electric (Invensys).
h. Siemens.

2.05 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) 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) Paragon Controls.

7. Duct Air Flow Measuring Stations

a. Located in a configuration and size equal to that of the duct it is installed.

b. The airflow traverse probe shall not induce a measurable pressure drop, nor amplify the sound level within the duct by its presence in the airstream.

c. Flow Straightener: Provide flow straightener as required by manufacturer of construction as needed to meet the application.

d. Range: Minimum 400 to 4,000 fpm.

e. Accuracy: Plus/minus 2.0 percent of the measured airflow.

f. Manufacturers:

1) Paragon Controls.

8. 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.

B. Water Flow Meter: Provide Water Flow Meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”.

C. BTU Meter: Provide BTU Meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”

D. Gas Flow Meter: Furnish gas flow meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”

2.06 HUMIDISTATS

A. Room Humidistats:

1. Performance Characteristics:

a. Throttling range: Adjustable 2 percent relative humidity.

b. Accuracy: Plus/minus 3 percent over the operating range.

1) Accuracy shall include temperature effects.

c. Operating range: 20 to 80 percent.

d. Drift: Less than 1 percent per year.

2. Construction:

a. Wall-mounted enclosure: Plastic, NEMA 250, Type 1.

b. Cover: Set point indication.

3. Output: Linear, proportional type over shielded cable pair, 4 - 20 mA or 0 – 10 Vdc signal..

B. Limit Duct Humidistat:

1. Insertion, two position switch type.
2. Performance Characteristics:
   a. Throttling range: Adjustable 2 percent relative humidity.
   b. Accuracy: Plus/minus 5 percent over the operating range.
      1) Accuracy shall include temperature effects.
   c. Operating range:
      1) High Limit Type: Minimum 50 to 95 percent.
   d. Drift: Less than 1 percent per year.
3. Construction:
   a. Enclosure: Metal, NEMA 250, Type 1.

2.07 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. Use thermistor or RTD type temperature sensing elements with 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.
2) Use RTD type sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
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) Non-adjustable, blank front panel.
2) Integral digital display with the following:
a) Indication of space temperature.
b) Setpoint adjustment to accommodate room setpoint.
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. Cover: Provide display indicating sensed humidity value.
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.
      b. 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.
      c. 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.
   3. Hydronic Pressure:
      a. Type: Unidirectional, fixed range.
      b. General Sensor Performance Characteristics:
         1) Accuracy: Plus/minus 1.0 percent of full scale.
         2) Thermal Effects: Temperature compensated minimum 30 to 150 F range. Zero and span shift of plus/minus 0.02 percent or less of full scale per degree F
         3) Long Term Thermal Stability: Plus/minus 0.5 percent full scale per year.

4) Range: Select sensor so that the scheduled differential pressure setpoint is near the midrange of the sensor pressure range.

c. Performance Characteristics for Chiller/Boiler Equipment Differential Pressure:
1) Application: Variable-Primary Flow Systems.
2) Accuracy: Plus/minus 0.05 percent of full scale.
3) Thermal Effects: Temperature compensated minimum 30 to 150 F range. Zero and span shift of plus/minus 0.02 percent or less of full scale per degree F.
4) Long Term Thermal Stability: Plus/minus 0.125 percent full scale per year for minimum 5 years.
5) Range: Select sensor so that the scheduled differential pressure setpoint is near the midrange of the sensor pressure range.
6) Manufacturers:
a) Rosemount, 3051S
b) Approved equal.

d. Construction:
1) Suitable for the media temperature and pressure.
2) Chiller/Boiler differential sensor shall have push button zero and span adjustments. No internal mechanical linkages shall be used in the transmitter.
3) Element: Diaphragm type, stainless steel.
4) Housing: Fire retardant glass-filled polyester, 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 Hydronic Equipment:
a. Differential Pressure Switch: Fixed range type with adjustable setpoint.
1) Range: Not greater than two times the design equipment differential pressure.
2) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered.
3) Contact Type: Single-pole, single-throw (SPST). Provide double-throw contacts to meet additional alarms required.
b. Flow Switch:
1) Thermal dispersion flow switch enclosed in insertion device, of material suitable for fluid encountered and magnetic setpoint coordinated with the desired flow rate.
a) Range: Sensitivity suitable for the maximum and minimum design flow rates of the system in which it is installed.

b) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered, with LED status indicators for visual switch indication.

c) Contact Type: Automatic reset upon regain of flow.

3. Status Inputs for Electric Motors:
   a. Binary Current Sensing Relay:
      1) Type: Split core with current transformers, adjustable and set to 175 percent of rated motor current.
      2) Self-powered 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. Leak Detection Sensors
   1. Leak detection sensors shall be stand alone as described in Division 23 Section, Common Work Results for HVAC". Monitor leak detection sensors as noted on the drawings.

2.08 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.

2.09 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.

2.10 ROOM PRESSURE CONTROLLER

A. Type: Room pressure control system with control panel and integral differential pressure sensor.

B. Features:

1. Backlit LCD screen which displays the following:
    a. Room pressure.
    b. Room status.
    c. Indicator lights for normal and alarm.
2. Touch-screen or button interface.
3. Visual and audible alarms.
    a. Include time delays for nuisance alarm reduction.
4. Alarm relay contacts.
5. Building automation system communication interface.
6. Provide with analog input from temperature and humidity sensor
7. Provide binary input from door switch and motion sensor.

C. Performance Requirements:
1. Pressure sensor:
    a. Accuracy: Plus/minus 10 percent of reading or plus/minus 0.25 percent of full scale.
    b. Resolution: Plus/minus 5 percent of reading, to the nearest 0.0001 inch W.C.
    c. Long Term Stability: Plus/minus 1 percent full scale per year.
    d. Range:
        1) Sensing: Minus 0.2 to 0.2 inches W.G.
        2) Minimum Compensated Temperature Range: 55 to 95 degrees F.
        3) Minimum Operating Humidity: 5 to 95 percent relative humidity.
2. Operation: The system shall alarm via audible and visual means upon loss of pressure relationship.

D. Construction:
1. Enclosure: Fire retardant plastic, UL 94 rated for V-0.

E. Manufacturers:
1. Accutrol
2. TSI Pressura.
3. Siemens.
4. setra.

PART 3 - EXECUTION

3.01 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.

3.02 EXISTING EQUIPMENT

A. Pneumatic Equipment: Where equipment is allowed to be reused for project scope as indicated on the drawings, verify the integrity and proper operation of equipment prior to reuse.
B. 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.

C. 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.

D. 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.

E. 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.

F. Indicator Gauges: Where these devices remain and are not removed, recalibrate and ensure reasonable accuracy.

G. 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.
   5. Control valves.

H. Patch holes and finish to match existing walls.

3.03 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. Coordinate with other contractors performing work to provide emergency power to all control devices required to operate on emergency power.
   1. Coordinate emergency power to BAS network control panels.
   2. Coordinate power wiring for smoke control equipment is installed in metallic conduit.

C. 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.

D. Sensors:
   1. Mount sensors rigidly and adequately for the environment within which the sensor operates.
   2. 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.
   3. 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.
   4. 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.

5. 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.
6. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 feet downstream.
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. Return 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 low-pressure tap tubing of the corresponding building static pressure sensor or the plenum.
    c. 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.
    d. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
    e. 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.
    f. 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. Adjust flow switch to meet sensitivity required to ensure minimum flow through the equipment.
12. Check and verify location of thermostats, humidistats, and exposed control sensors with plans and room details before installation. Locate 48 inches above floor. Align with adjacent lighting switches and humidistats.
    a. Install devices to meet ADA requirements unless otherwise noted on the plans.
13. Mount freeze protection thermostats using flanges and element holders.
    a. Install thermostat completely across the surface the thermostat serves.
14. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
15. Provide separable sockets for liquids and flanges for air bulb elements.
16. Provide thermostats in aspirating boxes in areas where flush mounting is required.
17. Provide guards on thermostats in areas indicated on the drawings.

18. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
19. 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.

E. Control Valves:
1. Do not install brass valves in open-loop systems.
2. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
3. Install flanges or unions to allow valve removal and installation.
4. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
5. Valve Orientation:
   a. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
   b. Install valves in a position to allow full stem movement.
   c. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.
6. Provide valves with position indicators where sequenced with other controls.
7. Tag valves in accordance with Division 23 Section, "Identification for HVAC Piping and Equipment."
8. Install a pressure/temperature port on each side of pressure independent control valves (PICVs) which are not factory provided with integral ports.

F. 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.

G. 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.
3. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer.

H. 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.

I. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

J. Provide an insulation standoff on control devices, cables, and other items that do not require flush mounting to ductwork, piping, or equipment.

K. Install room pressure monitoring system per manufacturer installation instructions. Provide additional rough-in and tubing for accessories such as pressure snubbers and remote annunciators required to perform the system functions. Schedule manufacturer representative to provide start up, testing, and owner operating instructions to owner.

3.04 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.

3.05 STARTUP AND DEMONSTRATION

A. Control Dampers and Valves:
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.

B. PI Control Valves:

1. Field verify installation and operating differential pressure range of all PI control valves.
2. Verify total system flow to be within plus/minus 10 percent of system design.
3. Verify correct individual performance for each valve as noted on the drawings.
4. Individual field adjustments for the PI control valve assembly shall be performed using the PI control valve manufacturer's documented procedures.

3.06 DAMPER SCHEDULE

SERVICE	RUSKIN MODEL	MATERIAL
Outside, Exhaust and Relief Air Control, Stairway and Shaft Vents	CD-50	Aluminum
Fire/Smoke Damper for Smoke Control	FSD-60	Galvanized Steel
Smoke Damper for Smoke Control	SD-60	Galvanized Steel
Corrosive Environments	CD-50-CE	Aluminum
Corrosive Environments	CD-36-CE	Stainless Steel
All Other	CD-356	Galvanized Steel

3.07 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.

3.08 CONTROL VALVE SCHEDULES

A. Allowable Valve Type and Size by Control Application:

VALVE TYPE	CONTROL APPLICATION MODULATING	TWO-POSITION
Globe	≤ 4 IN	≤ 2 IN
Characterized Ball	≤ 2 IN	≤ 2 IN
Butterfly	> 2 1/2 IN	≥ 2-1/2 IN

B. Allowable Valve Body Material by Service Application:

VALVE BODY MATERIAL	SERVICE APPLICATION CLOSED LOOP	OPEN LOOP
Bronze	Allowed	Allowed
Iron	Allowed	Allowed
Stainless Steel	Allowed	Allowed

C. Allowable End Connection by System Material:

1. Copper Tube:

a. 2-1/2 Inch and smaller: Threaded ends.

2. Steel Pipe:
   a. 2 Inch and Smaller: Threaded.
   b. 2-1/2 Inch and Larger:
      1) Flanged.
      2) Grooved ends for water systems.

D. Allowable End Connection by Size Schedule:

VALVE TYPE	END CONNECTION TYPE		
	THREADED	FLANGED	GROOVED
Globe	≤ 2-1/2 IN	≤ 4 IN	N/A
Characterized Ball	≤ 2-1/2 IN	≤ 3 IN	N/A
Butterfly	N/A	≥ 2-1/2 IN	≥ 2-1/2 IN

END OF SECTION 23 09 13

SECTION 23 09 23
DIRECT-DIGITAL CONTROL FOR HVAC

PART 1 - GENERAL REQUIREMENTS

1.01 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

1.02 RELATED REQUIREMENTS

A. Section 230010 – General Mechanical Requirements.
B. Section 230800 – Commissioning HVACR Systems.
C. Section 230913 - Instrumentation and Control Devices for HVAC.
D. Section 275313 - Clock Systems.
E. Section 281600 - Intrusion Detection.
F. Section 281300 - Access Control.
G. Section 283111 – Digital Addressable Fire Alarm Systems.

1.03 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.

1.04 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. Optional attendees include the Commissioning Agent and the Owner, Architect, and Engineer.

1.05 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.
B. ATU: Air Terminal Unit (e.g., VAV boxes, fan-powered boxes, fan coil units).
C. BAS: Building Automation System.
D. BTL: BACnet Testing Laboratories. Third party independent testing and listing program for devices which have been tested according to ASHRAE Standard 135.

E. 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

F. DDC: Direct Digital Control.

G. EMT: Electrical Metallic Tubing

H. High voltage: 50 volts or higher.

I. IP: Internet Protocol.

J. LAN: Local Area Network.

K. VLAN: Virtual Local Area Network.

L. Low voltage: Below 50 volts.

M. OSI: Open System Interconnection

N. PC: Personal Computer.

O. PICS: Protocol Implementation Conformance Statement.

P. 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.

1.06 CONTRACTOR RESPONSIBILITIES

A. Reference sections 230015, 230800, and 230913 for contractor responsibilities and coordination.

B. Reference Part 3 for additional electrical contractor responsibilities for BAS controls.

1.07 SUBMITTALS

A. Refer to Division 01 and Section 230010 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.
2. 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.
3. 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.
4. 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.
    a. Testing shall include power and communication trunk wiring.
    b. 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 riser diagram depicting locations of all 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.
2. Submit detailed schematic control drawings for each controlled device and equipment.
    a. Reference all control components to manufacturer make and model number.
    b. Include all control and power wiring with termination point (controller and terminal number).
    c. Include clearly indicated and written sequences of operation referenced to specific control components (e.g., "shall modulate valve V-3").
    d. Include default position (e.g., N.O., N.C., etc.) for all components where applicable.
    e. Clearly differentiate between existing components and new components.
    f. 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.
    g. The use of ”typicals” will be allowed where appropriate.
3. 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.
4. 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.
5. Submit methods and materials used to connect existing communications network.
6. 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.
7. Submit system identification nomenclature.
    a. Naming and numbering convention shall be consistent with the existing building BAS naming convention.
    b. Point names and naming convention shall be consistent with point names shown on the drawings. The HCA standard naming convention shall be used where a conflict between the standards and name on the drawings occurs.

c. Equipment tags shall be consistent with equipment tags shown on the drawings.

8. Indicate BAS 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.

F. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

G. 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.

H. 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.

I. 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.

J. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner’s name and registered with manufacturer.

K. Maintenance Materials:
   1. Refer to Division 01 for additional provisions.
   2. Extra Stock Materials: Two printer cartridges and cartons of printer paper.

1.08 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. Design system software under direct supervision of a Professional Engineer experienced in design of this Work and licensed at the State in which the Project is located.

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 this section with minimum 10 years experience approved by manufacturer.

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.

1.09 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 1 yearafter Substantial Completion and system acceptance, as defined in Part 3.

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. 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.

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

2.01 OWNER FURNISHED PRODUCTS

A. New Products: Johnson Controls shall be used on all projects on which the existing BAS is a Johnson Control System and on all new construction in which the new building is not associated with an acute care hospital that has either a Siemens or Schneider Electric (or associated legacy brand, see below) installed

B. Existing Products: The existing building is provided with an existing DDC front end.

2.02 MANUFACTURERS

A. Acceptable Manufacturers: Johnson Controls (JCI) Metasys (Facility Explorer is not acceptable), Siemens Apogee, or Schneider Electric StruxureWare

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 Section 230913 need not be manufactured by the above manufacturers.

2.03 SYSTEM DESCRIPTION

A. General:

1. Furnish and install a complete BAS.
2. 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.
    a. BACnet devices used in the BAS shall be BTL listed according to its device profile.
3. 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.
4. 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.
5. 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.
    a. The VLAN shall be digitally separate from all other networks and shall share a common physical cabling backbone.
    b. Coordinate with the Owner to configure Ethernet and IP router switches to accommodate the VLAN.
2. The BAS shall be connected to the facility LAN and shall permit an unlimited number of simultaneous users to access the system over the LAN, and to (based on password level) monitor parameters, change set points, set up trends, or start/stop controlled equipment.
    a. A remote user shall have this capability without having the system database loaded on his/her remote computer.
    b. Connection by remote Energy Management system shall be accommodated by allowing polling of BAS parameters over BACnet IP.

C. Network Integration:

The BAS/DDC shall use BACNet/IP protocol capable of communicating over an Ethernet system. It shall be capable of residing on the HCA Enterprise WAN/LAN by having an assigned IP address. BAS/DDC systems are required to permit a remote user with password access, monitor points and issue basic commands over the HCA WAN/LAN using a PC type terminal without the need for proprietary BAS/DDC software. The system database shall reside on

an owner-furnished server, not a PC. The user interface is to be installed on an owner-furnished workstation. Controls contractor to coordinate and verify with HCA Corporate FacilitiGroup Energy Service Center full BAS communication between the facility and ESC.

1. Provide gateways or other integration devices across networks with different communication protocol to provide a single network visibility and interoperability at the operator workstation.
    a. Coordinate communication protocol with each automation system specified.
2. Interoperable networks shall be capable of sharing all point and point information across networks to a single BAS front end.
3. Interoperable networks shall be capable of automatically downloading application program changes.
4. For integrated networks that cannot automatically download application program changes, provide a “hot link” to hop between the existing networks to accomplish application program changes. Provide link to separate network at the BAS front end summary page.

D. Critical System Requirements:
1. The BAS network shall contain redundancies related to its corresponding tier criticality as noted on the drawings:
    a. Tier 1 = Redundant emergency generator power.
        1) Coordinate with Division 26 for emergency generator power size and power duration.
2. All building level and field equipment controllers except for controllers on terminal units not serving critical spaces shall be provided with an uninterruptible power system (UPS) to allow for continuous operation of all equipment during loss of normal power until stand by power is achieved.
    a. Size the UPS to operate for a minimum of 15 minutes.
    b. Elements of the control system susceptible to power surges shall be protected by conditioners, suppressors or other approved means.
    c. Coordinate the size of the UPS with Division 26.
3. Requirements for Smoke Control Networks:
    a. Network controllers and components used for smoke control operations shall be U.L. 864 – UUKL rated.
    b. Control wiring used for smoke control operations shall be installed in metallic conduit.
    c. Control system shall be capable of communicating with the building’s fire alarm system to fulfill the sequences of operation specified in this section or on the drawings.
    d. The BAS Contractor shall provide a Fire Fighter’s Smoke Control Panel to manually control the smoke evacuation system. Reference Section 230913 for panel requirements.

E. Network Architecture: The BAS network architecture shall be based upon the OSI basic reference model in accordance with ISO 7498.
1. Acceptable Protocol:
    a. Application/Network Layer:
        1) BACnet protocol complying with ASHRAE Standard 135.
    b. Physical/Data Link Layer:
        1) Hard-wired type:
            a) Ethernet according to ISO 8802-2 protocol.
            b) EIA-485 Twisted Cable Pair according to Master Slave/Token-Passing (MS/TP) protocol.
            c) EIA-232 Cable according to Point-to-Point (PTP) protocol.

2.04 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 accessing all system data, independent of hardware technology.

B. PC Based Work Station:

1. Connected to server for full access to all system information.
2. Provide a PC for command entry, information management, network alarm management, and database management functions.

C. Hardware:

2.05 CONTROLLERS

A. Building Controllers

1. General:
   a. Input Power Requirements: 24Vac/dc.
   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. UPS with 15 minutes backup for all building level and field equipment level controllers except controllers on terminal units not serving critical spaces
   g. Utilize real-time clock for scheduling.
   h. Continuously check processor status and memory circuits for abnormal operation.
   i. Monitor and assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
   j. Communication with other network devices to be based on assigned protocol.
   k. 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. Conditioned Space:
      1) Mount within NEMA 1 dustproof enclosures.
      2) Rated for operation at 32 to 120 degrees F.
4. Local Keypad and Display for each Controller:
   a. Use for interrogating and editing data.
   b. System security password prevents unauthorized use.

c. If the manufacturer does not normally provide a keypad and display for the controller, provide software and interface cabling needed to use a portable operator terminal for the system.

5. 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.
6. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
7. 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.
8. 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.

B. Custom Application Controllers
1. General:
   a. Input Power Requirements: 24Vac/dc.
   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.
   j. UPS with 15 minutes backup for all building level and field equipment level controllers except controllers on terminal units not serving critical spaces
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. Conditioned Space:
      1) Mount within NEMA 1 dustproof enclosures.
      2) Rated for operation at 32 to 120 degrees F.

4. Local Keypad and Display for each Controller:
    a. Use for interrogating and editing data.
    b. System security password prevents unauthorized use.
    c. If the manufacturer does not normally provide a keypad and display for the controller, provide software and interface cabling needed to use a portable operator terminal for the system.
5. 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.
6. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
7. 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.
8. 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. Application Specific Controllers
1. General:
    a. Input Power Requirements: 24Vac/dc.
    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.
    g. UPS with 15 minutes backup for all building level and field equipment level controllers except controllers on terminal units not serving critical spaces
2. Communication:
    a. 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.
        2) The capabilities of the portable service terminal shall include, but not be limited to the following:
            a) Display temperatures

b) Display status
c) Display setpoints
d) Display control parameters
e) Override binary output control
f) Override analog setpoints
g) Modification of gain and offset constants

3. Anticipated Environmental Ambient Conditions:
   a. 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. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.
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.

D. 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. 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.

5. Binary Outputs:
   a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
   b. Binary Outputs for Fire-Fighter Control Panel:
      1) Outputs provided with three position (On/Off/Auto) override switches.
      2) Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.
6. Analog Outputs:
   a. Monitoring signal provides a 0 to 10 Vdc or a 4 to 20 mA output signal for end device control.
   b. Drift to not exceed 0.4 percent of range per year.
   c. Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.06 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Power Wiring
   1. 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 and Line Filtering:
   1. Power Supplies:
      a. 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.
      b. Limit connected loads to 80 percent of rated capacity.
      c. Match DC power supply to current output and voltage requirements.
      d. Power supplies shall be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
      e. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
      f. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
      g. Operational Ambient Conditions: 32 to 120 degrees F.

h. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
i. Line voltage units UL recognized and CSA approved.

2. Power Line Filtering:
a. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
b. Minimum surge protection attributes:
1) Dielectric strength of 1000 volts minimum.
2) Response time of 10 nanoseconds or less.
3) Transverse mode noise attenuation of 65 dB or greater.
4) Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

D. 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.

E. Splices
1. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers that maintain the integrity of the shielding.

F. 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.

G. 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.

2.07 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: 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. 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. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Provide actions for all possible situations.
2) Text shall be modular and structured.
3) Text shall be commented.

b. Graphic-based:

1) Provide actions for all possible situations.
2) Graphics shall be documented.

c. Parameter-based:

1) Provide actions for all possible situations.
2) Parameters shall be documented.

D. Operating System:

1. Concurrent, multi-tasking capability.
2. Provide with the latest server operating system release.
3. 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.

E. System Graphics:

1. Format.

a. All graphics shall be in conformance to the HCA guidelines Appendix B

2. Custom Trend Logs:

a. Maintain trend information for 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.

a) 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.

2) Retrievable for use in reports, spreadsheets and standard database programs.

3) Archivable on LAN accessible storage media including the following:

a) Hard disk.

b) Raid array drive.

c) Virtual cloud environment.

4) 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.

3. Alarm and Event Log:
   a. Enable all system alarms and change of states to be viewed from any system location.
   b. List events chronologically.
   c. List alarm priority.
   d. Allow operator with proper security to acknowledge and clear alarms. Log operator and time when alarm is acknowledged.
   e. Archive alarms not cleared by operator to the workstation.
4. 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.
5. 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.
6. Reports and Logs:
   a. Reporting Package:
      1) Allows operator to select, modify, or create reports.
      2) Definable as to data content, format, interval, and date.
         a) Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.
      3) Provide ability to obtain real-time logs of all objects available by type or status such as alarm, lockout, normal, etc.
      4) Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
      5) 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 Intervals and 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 building automation system.

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 natural gas 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.

e. Daily Operating Condition of Chiller(s): Program a daily report that shows the operating condition of each chiller as recommended by ASHRAE Standard 147. Reference the control drawings for the points that shall be included in the log report.

7. 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.

F. Workstation Applications Editors:

1. Provide editing software for all workstation system applications at the PC workstation.
2. Edited applications shall be automatically downloaded and executed at the building 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:
    1) Configuration.
    2) Name.
    3) Control parameters.
    4) Set-points.
    5) Schedules.
9. Scheduling Application Features:
    a. Allow scheduling down to the zone or room level.
    b. Monthly calendar indicates schedules, holidays, and exceptions.
    c. Allows several related objects to be grouped, scheduled, and copied to other objects or dates.
    d. Start and stop times adjustable from master schedule.
    e. Schedule expiration.
    f. Temporary overrides of systems with user adjustable time-out.
    g. Provide minimum three tiers of priorities for scheduling.
        1) Priority 1: Event, temporary, or override.
        2) Priority 2: Calendar.
        3) Priority 3: Default.
    h. 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.
    i. 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) Acceptable Languages:

a) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.

b) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.

2) Programming Functions:

a) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.

b) Allows the development of independently, executing, program modules designed to enable and disable other modules.

c) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.

d) 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.

e) 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.

f) 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.

g) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

2.08 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. Provide a BAS paging and email feature with the capability to telephone/email selected facility maintenance personnel to notify them of critical BAS alarms.
   2. General Alarm Parameters:
      a. Binary object is set to alarm based on the operator specified state.
      b. Analog object to have high/low alarm limits.
      c. All alarming is capable of being automatically or manually disabled.
      d. Alarm Reporting:
         1) Operator determines action to be taken for alarm event.
         2) Alarms to be routed to appropriate workstation.
         3) Reporting Options:
            a) Start Programs.
            b) Print.
            c) Logged.
            d) Custom messaging.
            e) Graphical displays.
            f) Dial out to workstation receivers via system protocol.

F. Maintenance Management:
   1. System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.

G. Sequencing:
   1. Application software based upon specified sequences of operation on the control drawings.

H. 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.

I. Staggered Start Application:
   1. Prevents all controlled equipment from simultaneously restarting after power outage.
   2. Order of equipment startup is user selectable.

J. Energy Calculations:
   1. Refer to HCA guidelines for energy calculations and required graphics.

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:
   1. 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.
         1) Generate unique, user-specified messages when the limit is reached.
      c. 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

3.01 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 is 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.

3.02 INSTALLATION

A. Coordination:

1. The BAS Contractor shall execute his 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 other contractors performing work to provide emergency power to all control devices required to operate on emergency power.

B. Network Arrangement:
   1. Use the following physical/data link communication bus for the following types of communication:
      a. Communication between operator workstation(s) and building controller(s):
         1) Ethernet.
         2) MS/TP.
      b. Communication between building controller(s) and application specific and custom application controllers:
         1) MS/TP.
         2) PTP.

C. Web Services Enabled Network:
   1. 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.
   2. If the Owner has no preference, within the main BAS control panel.
   3. 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.

D. 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.
   5. Control wiring routed in wall cavities shall be installed in conduit.
   6. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
   7. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.

E. Controllers
   1. 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.
   2. 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.
   3. 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.

4. All CAV/VAV Terminal Box Controller parameters to be mapped to the front end.

F. Wiring:

1. All control and interlock wiring shall comply with national and local electrical codes.
2. Wire all safety devices through both hand and auto positions of motor starting device to ensure 100 percent safety shut-off.
3. Provide interlock wiring between devices as indicated on the control drawings.
4. Provide electrical wiring for relays (including power feed) for temperature and pressure indication.
5. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.
6. 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.
10. 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.
11. All wiring in mechanical, electrical, service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 10 feet.
12. 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).
13. 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.
14. 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.
15. All wire-to-device and wire-to-wire connections shall be made at a terminal block or terminal strip.
16. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
17. 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.
18. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
19. Install plenum wiring in sleeves where it passes through floors and walls. Maintain fire rating at all penetrations.
20. 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.
21. Include one pull string in each raceway 1 inch and larger.

22. Use coded conductors throughout with conductors of different colors.
23. 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.
24. 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).
25. 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.
26. Install insulated bushing on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
27. Terminate all control and/or interlock wiring and maintain updated (as-built) wiring diagrams with terminations identified at the job site.
28. 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.
29. Terminate BAS comm bus cable shield between controllers per manufacturer recommendations.
30. 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.
31. 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.
32. 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.

G. 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 install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
4. 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.
5. 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.
6. Do not exceed maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer during installation.
7. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
8. 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.
9. Ground (earth ground) all shields at one point only, to eliminate ground loops.

10. All runs of communications wiring shall be unspliced length when that length is commercially available.
11. Terminate shielded cable splices in accessible locations. Harness cables with cable ties.
12. Make all wire-to-device and wire-to-wire connections at a terminal block or terminal strip.
13. Label all communications wiring to indicate origination and destination data.
14. Ground coaxial cable in accordance with NEC regulations.
15. 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 100 pF per meter (30 pF per foot.)
    b. The maximum length of an MS/TP segment shall be 4000 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.

H. 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.

3.03 STARTUP AND DEMONSTRATION

A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing the BAS in permanent operation.
1. 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.
2. Coordinate with Owner the setup of logins, passwords, and security level access for individuals requiring access to the BAS.

B. The Controls Subcontractor shall furnish the test and balance Contractor with the appropriate DDC system software available to assist in the test and balance process.

C. The Controls Subcontractor provide a technician for 8 hours to assist/train the TAB technician in the coordination/ interface of the BAS with the TAB activities.

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. 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. 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.

H. 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.

I. 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.

J. 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.

3.04 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for one year from Date of Substantial Completion.

3.05 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 sixteen 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. Content: Training shall include but not be limited to:

1. Day-to-day Operator Training:
    a. Overview of the system and/or equipment as it relates to the facility as a whole.
    b. Proficiently operate the BAS.
    c. Understand BAS architecture and configuration.
    d. Understand BAS components.
    e. Understand system operation, including BAS control and optimizing routines (algorithms).
    f. Operate the workstation and peripherals.
    g. Log on and off the system.
    h. Access graphics, point reports, and logs.
    i. Adjust and change system set points, time schedules, and holiday schedules.
    j. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
    k. Understand BAS drawings and Operation and Maintenance manual.
    l. Understand the job layout and location of control components.
    m. Access data from BAS controllers and ASCs.
    n. Operate portable operator's terminals.
    o. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
2. Advanced Operator Training:
    a. Make and change graphics on the workstation.
    b. Create, delete, and modify alarms, including annunciation and routing of these.
    c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals.
    d. Create, delete, and modify reports.
    e. Add, remove, and modify system's physical points.
    f. Create, modify, and delete programming.
    g. Add panels when required.
    h. Add operator interface stations.
    i. Create, delete, and modify system displays, both graphical and others.
    j. Perform BAS field checkout procedures.
    k. Perform BAS controller unit operation and maintenance procedures.
    l. Perform workstation and peripheral operation and maintenance procedures.
    m. Perform BAS diagnostic procedures.
    n. Configure hardware including PC boards, switches, communication, and I/O points.
    o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
    p. Adjust, calibrate, and replace system components.
3. System Manager/Administrator Training:
    a. Maintain software and prepare backups.
    b. Interface with job-specific, third-party operator software.

c. Add new users and understand password security procedures.

4. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

D. 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.

E. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes piping systems for hot water heating, chilled water cooling, condenser water, make-up water for these systems, blow-down drain lines, and condensate drain piping. Piping materials and equipment specified in this Section include:
   1. Pipes

B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Division 2 Section "Earthwork," for trenching and backfilling materials and methods for underground piping installations.
   2. Division 3 “Concrete” for concrete, reinforcement and formwork for concrete equipment pads.
   3. Division 7 Section "Penetration Firestopping," for materials and methods for fire barrier penetrations.
   4. Division 7 Section "Joint Sealers," for materials and methods for sealing pipe penetrations through basement and foundation walls.
   5. Division 23 Section "Identification for HVAC Piping & Equipment," for labeling and identification of hydronic piping.
   6. Division 23 Section "Common Work Results for HVAC" for materials and methods for wall and floor penetrations and equipment pads.
   7. Division 23 Section "Basic Piping Material and Methods," for materials and methods for dielectric fittings, and mechanical sleeve seals.
   8. Division 23 Section "General Duty Valves for HVAC Piping," for materials and methods for installing hydronic piping valves.
   9. Division 23 Section “Hydronic Specialties”, for materials and methods for installing hydronic specialties.
   10. Division 23 Section "Hangers & Supports for HVAC Piping & Equipment," for insulation shields, saddles and materials and methods for hanging and supporting hydronic piping.
   11. Division 23 Section "HVAC Insulation," for materials and methods for insulating hydronic piping.
   12. Division 23 Section “HVAC Water Treatment” for water treatment equipment, controls and chemicals.
   13. The Division 23 Contractor shall not use mechanically joined hydronic piping systems for hydronic piping in lieu of welded, threaded or flanged piping methods.
      a. Exception: Grooved couplings may be used at equipment connections where specified for vibration isolation control only.

1.02 SYSTEM DESCRIPTION

A. General: The hydronic piping systems are the "water-side" of an air-and-water or all-water heating and air conditioning system. Hydronic piping systems specified in this Section include 2- or 4-pipe, hot water and chilled water piping system, and condenser water piping system. These systems are classified by ASHRAE as Low Water Temperature, Forced, Recirculating systems.

B. 2-Pipe System: The 2-pipe system includes chilled water and hot water supply and return piping mains in a closed loop, connecting the boilers and chillers to the terminal heat transfer units by means of primary and/or secondary piping loops. Circulation is accomplished by constant or variable volume, primary and/or secondary pumps in parallel or series configuration. Design

flow rates and water temperatures are specified in the various equipment specifications and schedules. Control sequences and temperature reset schedules are specified in the temperature control specifications.

C. 4-Pipe System: The 4-pipe system includes independent chilled water and hot water supply and return piping mains in a closed loop, connecting the boilers and chillers to the terminal heat transfer units by means of primary/secondary piping loops. Circulation is accomplished by constant or variable volume, primary and/or secondary pumps in parallel or series configuration. Design flow rates and water temperatures are specified in the various equipment specifications and schedules. Control sequences and temperature reset schedules are specified in the temperature control specifications.

D. Condenser Water System: This system is an open piping loop connecting the chillers to the cooling tower. Circulation is accomplished by means of parallel, constant volume pumps. Design flow rates and water temperatures are specified in the various equipment specifications and schedules. Control sequences and temperature reset schedules are specified in the temperature control specifications.

1.03 SUBMITTALS

A. Submit in accordance with Division 01 Submittals and Division 23 General Mechanical Requirements.

B. Submit a schedule of proposed materials for each hydronic system. Include the following:

1. Application (e.g., Chilled Water, Hot Water, etc.).
2. Location (e.g., above grade, below grade).
3. Pipe size range.
4. Materials corresponding to the pipe size range.
5. Connection methods (e.g., threaded, flanged, grooved, welded, etc.).

C. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.

D. Certification of compliance with ASTM and ANSI manufacturing requirements for pipe and fittings.

E. Reports specified in Part 3 of this Section.

F. Coordination Drawings:

1. Coordination Drawings: 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:
   a. Suspended ceiling components.
   b. Other building services.
   c. Structural members.

G. Record Drawings:

1. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser water, and heating hot water system and other piping systems and equipment.
2. One complete set of drawings in electronic AutoCAD and pdf format.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: comply with the provisions of the following:

1. ASME B 31.9 "Building Services Piping" for materials, products, and installation.
2. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

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

1.05 COORDINATION

A. Coordinate the installation of pipe sleeves for foundation wall penetrations.

PART 2 - PRODUCTS AND MATERIALS

2.01 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3 Article "PIPE APPLICATIONS" for identification of where the below materials are used.

B. Drawn Temper Copper Tubing: ASTM B 88, Type L.

C. Steel Pipe:

1. NPS 2 and Smaller: ASTM A 53, Type E (electric resistance welded) or Type S (seamless), Grade B, Schedule 40, black steel, plain ends.
2. NPS 2-1/2 through NPS 10 ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule 40, black steel, plain ends.
3. NPS 12 through NPS 24 ASTM A 53, Type E (electric-resistance welded) or Type S (seamless), Grade B, Schedule STD, black steel, plain ends.
    a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 and smaller and electric-resistance welded for NPS 2-1/2 and larger.

2.02 FITTINGS

A. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

B. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

C. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.

D. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

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

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

G. Steel Flanges and Flanged Fittings: ANSI B16.5, Class 150 for low pressure service and Class 300 for high pressure service, including bolts, nuts, and gaskets of the following material group, end connection and facing:

1. Material Group: 1.1.
2. End Connections: Butt Welding.
3. Facings: Raised face.
4. Gasket Materials:
    a. Steam service: Flexitallic Style CG, TEADIT Style 913, Garlock Flexseal Style RW, Lamons SpiraSeal Style WR, or Leader Style LG-13.
    b. Chilled water, condenser water, steam condensate, and heating hot water: Style IFG 5507 as manufactured by Garlock or approved equivalent.
    c. Refrigerants: Style IFG 5500 as manufactured by Garlock or approved equivalent.

H. Unions: ANSI B16.39 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. Threads shall conform to ANSI B1.20.1.

I. Dielectric Unions, Waterway Fittings and Flanges: As specified in Division 23 “Basic Piping Materials and Methods.”

2.03 JOINING MATERIALS

A. Reference Section “Basic Piping Materials and Methods” for basic joining materials.

B. Brazing Filler Metals: AWS A5.8, Classification BAg 1 (Silver).

1. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

2.04 VALVES

A. General duty valves (i.e., gate, globe, check, ball, and butterfly valves) are specified in Division 23 Section "General-Duty Valves for HVAC Piping." Special duty valves are specified in Division 23 Section “Hydronic Specialties”.

2.05 ANTIFREEZE

A. Provide propylene glycol, as specified in Part 3, with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions to protect the piping circuit and connected equipment from physical damage from freezing or corrosion.

B. Coordinate corrosion inhibitors with Division 23 Section “HVAC Water Treatment” to provide an integrated water treatment and piping protection solution.

PART 3 - EXECUTION

3.01 PIPE APPLICATIONS

A. Chilled water and heating hot water may be all standard weight black steel or a mixture of Type L hard copper for piping 1″ and less, steel or copper pipe from 1-1/4″ to 2″, and steel for piping 2-1/2″ and larger. Condenser water shall be standard weight black steel.

B. Steam piping shall be standard weight black steel. Steam condensate and pumped condensate return piping shall be schedule 80 black steel. Piping for steam and steam condensate shall be seamless; other piping may be electric-resistance welded.

C. Type L soft copper may be used for run-outs to room terminals.

D. Chemical feed lines shall be Schedule 80 PVC for cooling towers and Schedule 10 stainless steel for boilers.

E. Aquatherm UV piping with an outer coating of black polyethylene may be used as an alternate on outdoor piping.

3.02 PIPING INSTALLATIONS

A. 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.

B. Use fittings for all changes in direction and all branch connections. Provide long radius elbows with a minimum centerline radius of 1-1/2 times the pipe diameter. Short radius elbows with a minimum centerline radius of 1 times the pipe diameter may be used only where space does not permit the long radius elbows.

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

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

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 insulation and servicing of valves.

G. 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.

H. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.

I. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 7 Section “Penetration Firestopping” for special sealers and materials.

J. Exterior Wall Penetrations: Seal pipe penetrations through exterior wall constructions with sleeves, packing, and sealant. Refer to Division 23 Section “Common Work Results for HVAC” for additional information.

K. Underground Exterior Wall Penetrations: Seal pipe penetrations through underground exterior walls with sleeves and mechanical sleeve seals. Refer to Division 23 Section “Basic Piping Materials and Methods” for additional information.

L. 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 23 Section "Common Work Results for HVAC” for special sealers and materials.

M. Install piping at a uniform grade of 1 inch in 40 feet upward in the direction of flow.

N. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.

O. Install branch connections to mains using Tee fittings in main with take-off out the top or side of the main unless otherwise shown on the drawings. Up-feed risers shall have take-off out the top of the main line.

P. Bull-head tees are prohibited. Do not install tee fittings in such a way that the flow through the branch leg equals the sum of the flows through the two main legs.

Q. Install unions in pipes 2 inch and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

R. Install flanges on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

S. Install flexible connectors at inlet and discharge connections to pumps (unless otherwise indicated) and other vibration producing equipment. Omit flexible connectors if replaced by series of three grooved couplings on projects where grooved pipe is used.

T. Install strainers on the supply side of each pressure reducing valve, pressure regulating valve, pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2 inch and larger.

U. Anchor piping to ensure proper direction of expansion and contraction.

3.03 PREPARATION OF FOUNDATION FOR BELOW GROUND WATER DISTRIBUTION PIPE AND FITTINGS

A. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.

B. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with clean sand or pea gravel to indicated invert elevation.

C. Pipe Beds:

1. Provide 6” thick sand pipe bed underneath and around sides of pipe, up to middle half of the pipe, including fittings. Tamp bed with mechanical tamper to 85% to 95% compaction. Provide first layer of sand backfill 6” above pipe, tamp backfill with mechanical tamper to 85% to 95% compaction.
2. For piping with rock trench bottoms, provide sand pipe bed 6” underneath and around sides of pipe, including fittings.
3. Provide backfill above top of pipe bed as required for field conditions. Refer to Division 15 Section

3.04 HANGERS AND SUPPORTS

A. General: Hanger, supports, and anchors devices are specified in Division 23 Section "HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT." Conform to the table below for maximum spacing of supports:

1. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.
2. Adjustable roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe roller complete - MSS Type 44 for multiple horizontal runs, 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. 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 - In.	Steel Pipe Max. Span - Ft.	Copper Tube Max. Span - Ft.	Min. Rod Dia. - In.
Up to 3/4	7	5	3/8
1	7	6	3/8
1-1/4	7	7	3/8
1-1/2	9	8	3/8
2	10	8	1/2
2-1/2	11	9	1/2
3	12	10	1/2
4	14	12	5/8 (1/2 for copper)
5	16	13	5/8 (1/2 for copper)
6	17	14	3/4 (5/8 for copper)
8	19	16	7/8 (3/4 for copper)
10	20	18	7/8 (3/4 for copper)
12	23	19	7/8 (3/4 for copper)
14	25		1
16	27		1
18	28		1 1/4
20	30		1-1/4
24	32		1-1/4
30	33		1-1/4

D. Install PVC and CPVC supports and hangers per manufacturer’s recommendations.

E. Support vertical runs at roof, at each floor, and at maximum 15-foot intervals between floors.

F. Install a support within one foot of each change of direction.

G. Space supports not more than five feet apart at valves, strainers or piping accessories in piping larger than 2”.

3.05 PIPE 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 at piping specialties before brazing.

2. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.
3. Heat joints using oxy-acetylene torch. Heat to proper and uniform temperature.

C. 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.
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 threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

D. Welded Joints: Comply with the requirement in ASME Code B31.9-"Building Services Piping."

E. 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 using torque wrench.

F. CPVC Joints: Prepare surfaces to be solvent cemented by wiping with a clean cloth moistened with acetone or methylethyl keytone. Solvent cement joints in accordance with ASTM D2846.

3.06 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 gate, ball, and butterfly valves.
2. Throttling duty: use globe, ball, and butterfly valves.
3. Install shut-off duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.
4. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.

B. Special Duty Valve Applications: Special duty valve applications are specified in Division 23 Section “Hydronic Specialties”.

3.07 FIELD QUALITY CONTROL

A. Preparation for testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:
1. Leave joints including welds uninsulated and exposed for examination during the test.
2. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
3. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
4. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.

B. Pressure Testing: Test hydronic piping as follows:

1. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
2. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of the liquid.
3. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
4. Subject piping systems other than ground source heat pump loop systems to a hydrostatic test pressure which at every point in the system is 1.5 times the maximum system design pressure but not less than 100 psi. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix I of ASME B31.9, Code For Pressure Piping, Building Services Piping.
5. After the hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.
6. Subject ground source heat pump loop systems to water test pressure of 100 psi for 30 minutes. Testing shall be implemented prior to trench backfilling. Compare actual flow and pressure drop to design values and make system corrections as required to bring actual values to within 10% of design.
7. Provide test reports summarizing the test procedures and results of the tests.

C. Flushing:
1. After satisfactory pressure test is obtained, flush piping system using a minimum velocity of 4 FPS through all portions of the system.
2. Make all provisions required to isolate HVAC equipment, coils, control valves, automatic flow control valves, pressure independent control valves, and balance valves during flushing.
3. Isolate new pipe from existing pipe during flushing.
4. Provide temporary valves, connections, and bypasses where required.
5. System pumps may be used for flushing. Where system pumps are not used, provide temporary pumps with temporary connections.
6. Continue flushing until discharge water shows no discoloration and strainers are no longer collecting dirt and other foreign materials.
7. Upon completion of flushing, drain all water from system at low points, and remove, clean, and replace strainers.

D. Fluid Testing: After filling the system as described under Paragraph “Startup”, perform the following fluid test procedures:
1. Circulate the fluid for a minimum of 24 hours with all pumps operating and with shutoff valves and control valves in wide open position to ensure thorough mixing of the antifreeze or glycol solution throughout the system.
2. Remove fluid from a minimum of three different locations and test fluid samples at an independent testing agency for percentage of antifreeze or glycol. Coordinate with the testing agency for amount of sample needed for proper testing.
3. If any sample does not meet the specified percentages, remove sufficient fluid from the system, add antifreeze or glycol as required to achieve the specified percentage and repeat the circulation and testing procedures specified above.

4. After the samples meet the specified percentages, submit to the Owner and Engineer signed and dated test report(s) from independent testing agency that document the location of the sample and the results of the fluid test.
5. One month prior to end of the warranty period, Contractor shall submit samples to an independent testing agency to test the fluid for percentage of antifreeze or glycol. If the test samples have the specified percentage, submit copies of the test reports to the Owner and Engineer as described above in Paragraph 4. If any sample does not meet the specified percentage, Contractor shall perform the work described above in Paragraphs 3 and 4.

3.08 ADJUSTING AND CLEANING

A. Concentration:
   1. As recommended by manufacturer.
B. Hot Water Heating Systems:
   1. Apply heat while circulating, slowly raising temperature to 160 F and maintain for 12 hours minimum.
   2. Remove heat and circulate to 100 F or less, drain systems as quickly as possible.
   3. Refill with clean water and repeat until system cleaner is removed.
C. Chilled Water and Closed Loop Condenser Water Systems:
   1. Circulate for 48 hours, then drain systems as quickly as possible.
   2. Refill with clean water, circulate for 24 hours, then drain.
   3. Refill with clean water and repeat until system cleaner is removed.
D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Engineer.
E. Flush open systems and glycol filled closed systems with clean water for one hour minimum. Drain completely and refill.
F. Remove and clean or replace strainer screens.
G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.
H. After cleaning system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
I. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

3.09 HEATING AND COOLING WATER FLUSHING

A. Before startup of new chilled water or heating systems perform cleaning, flushing and draining procedures designed to clean and verify by testing that the systems are clean prior to circulating through new clean components, control valves, coils, pumps, etc. or connecting the new system to an existing system. Utilize flushing connections at AHU coils, chillers, and at end-of-mains for hot water piping. Close valves at coils and chillers and flush systems through equipment/coil bypass connections. Drawings shall show flushing bypass connections and valves at all coils and equipment. Show flushing connections in hot water piping at end of piping run(s) on each floor and at major branches on the ancillary floors. After flushing systems, close flushing valves, cut bypass connections and cap piping at end of flushing valves. On VAV boxes, open valves to boxes and flush through hose bib connection at each box y-strainer.

B. Cleanness of the system shall be determined by water sampling performed by the water management chemical engineer and witnessed and approved in writing by the General Contractor’s quality control representative.

C. Permanent facility pumps should not be used for circulating the cleaning water. However if it is impractical to use temporary pumps, the permanent facility pump may be used provided

that the pump is unconditionally warranted for two years, parts and labor, after the date of substantial completion by the mechanical contractor.

3.10

3.11 STARTUP

A. Fill system and perform initial chemical treatment. For systems with antifreeze or glycol, fill systems with specified percentages.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean strainers.
3. Check pump for proper direction of correct improper wiring.
4. Set automatic fill valves for required system pressure.
5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Check operation of automatic bypass valves.
8. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
9. Lubricate motors and bearings.

END OF SECTION 23 21 13

SECTION 23 21 16
HYDRONIC SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes hydronic specialties for hot water heating, chilled water cooling, condenser water, make-up water for these systems, blow-down drain lines, and condensate drain piping. Equipment specified in this Section include:

1. Circuit Balancing Valves
2. Automatic Flow-Control Valves
3. Safety Relief Valves
4. Pressure Reducing Valves
5. Air Vents (Manual and Automatic)
6. Diverting Fittings
7. Y-Pattern Strainers
8. Basket Strainers
9. Metal Flexible Connectors
10. Rubber Flexible Connectors
11. Combination Piping Packages (Coil Kits).

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

1. Division 3 “Concrete” for concrete, reinforcement and formwork for concrete equipment pads.
2. Division 23 Section "Common Work Results for HVAC" for materials and methods for wall and floor penetrations and equipment pads.
3. Division 23 Section "Basic Piping Material and Methods," for materials and methods for flexible connectors and mechanical sleeve seals.
4. Division 23 Section “Common Motor Requirements for HVAC Equipment” for motors related to chemical feeding equipment.
5. Division 23 Section “Hydronic Piping” for material and methods for installation of hydronic piping systems.
6. Division 23 Section "General Duty Valves for HVAC Piping," for materials and methods for installing hydronic piping valves.
7. Division 23 Section "Hangers & Supports for HVAC Piping & Equipment," for insulation shields, saddles and materials and methods for hanging and supporting hydronic piping.
8. Division 23 Section "HVAC Insulation," for materials and methods for insulating hydronic piping.
9. Division 23 Section “HVAC Water Treatment” for water treatment equipment, controls and chemicals.
10. Division 23 Section “Instrumentation and Control Devices for HVAC” for control valves.

1.02 SUBMITTALS

A. Submit in accordance with Division 01 Submittals and Division 23 General Mechanical Requirements.

B. Product Data, including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties and accessories, and installation instructions for each hydronic specialty and special duty valve specified.

1. Furnish flow and pressure drop curves for diverting fittings and circuit balancing valves, based on manufacturer's testing.
2. Cooling tower basin sweeper piping layout and assembly drawings for basin sweeper systems. Include all dimensions, piping, water jets, couplings, valves, pressure gauges, and other components required to assemble the complete sweeper system inside the cooling tower basin.

C. Maintenance Data for hydronic specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 1 and Division 23 Section "General Mechanical Requirements."

D. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.

E. Certification of compliance with ASTM and ANSI manufacturing requirements for hydronic specialties.

1.03 QUALITY ASSURANCE

A. ASME B 31.9 "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

B. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; Current Eedition.

C. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

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

E. AWWA Standards for governing filter media; American Water Works Association, Current Edition.

F. NSF Standards for governing filter media; National Sanitation Foundation (NSF) International, Current Edition.

1.04 COORDINATION

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

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

1. Circuit Balancing Valves:
    a. American Wheatley.
    b. Armstrong Fluid Technology.
    c. Bell & Gossett; Xylem.
    d. Caleffi.
    e. Griswold Controls.
    f. Hays Fluid Controls.
    g. IMI Hydronic Engineering.
    h. Nexus Valve.
    i. Nibco Inc.
    j. Pro Hydronic Specialties.
    k. Taco, Inc.

l. Victaulic (TA Series).

2. Safety Relief Valves:
   a. American Wheatley.
   b. Armstrong International.
   c. Bell & Gossett; Xylem.
   d. Caleffi.
   e. Keckley.
   f. Spence Engineering Company, Inc.
   g. Spirax Sarco.
   h. Watts Water Technologies.
3. Pressure Reducing Valves:
   a. American Wheatley.
   b. Armstrong International.
   c. Bell & Gossett; Xylem.
   d. Caleffi.
   e. Keckley.
   f. Spence Engineering Company, Inc.
   g. Watts Water Technologies.
4. Air Vents (manual and automatic):
   a. American Wheatley.
   b. Amtrol, Inc.
   c. Armstrong International.
   d. Bell & Gossett; Xylem.
   e. John Wood Company.
   f. Nexus Valves.
   g. Spirax Sarco.
   h. Taco, Inc.
5. Diverting Fittings:
   a. Amtrol, Inc.
   b. Armstrong Fluid Technology.
   c. Bell & Gossett; Xylem.
   d. Taco, Inc.
6. Y-Pattern Strainers:
   a. American Wheatley.
   b. Armstrong International.
   c. Hoffman Specialty; Xylem.
   d. Keckley.
   e. Metraflex Co.
   f. Mueller Steam Specialties.
   g. Spirax Sarco.
   h. Nexus Valve.
   i. Watts Water Technologies.
7. Basket Strainers:
   a. American Wheatley.

b. Keckley.
c. Metraflex Co.
d. Spirax Sarco.

8. Metal Flexible Connectors:
   a. American Wheatley.
   b. Duraflex.
   c. Hyspan Precision Products.
   d. Mason Industries, Inc.
   e. Flexicraft Industries.
   f. Metraflex Co.
   g. Unaflex, Inc.
9. Rubber Flexible Connectors:
   a. American Wheatley.
   b. General Rubber Corp.
   c. Mason Industries, Inc.
   d. Mercer Rubber Co.
   e. Metraflex Co.
   f. Proco Products, Inc.
   g. Unaflex, Inc.
   h. Duraflex.
   i. Flexicraft Industries.

2.02 GENERAL DUTY VALVES

A. General duty valves (i.e., gate, globe, check, ball, and butterfly valves) are specified in Division 23 Section "General-Duty Valves for HVAC Piping." Special duty valves are specified below by their generic name; refer to Part 3 Article "VALVE APPLICATION" for specific uses and applications for each valve specified.

2.03 SPECIAL DUTY VALVES

A. Circuit Balancing Valves: Valve shall be rated for 125 psig water working pressure, 250 deg F maximum operating temperature and shall be bronze body with plug or globe style valve and calibrated orifice. Provide with connections for portable differential pressure meter with integral check valves and seals. Valve shall have integral pointer and calibrated scale to register degree of valve opening. Valve shall have position indication readout and built-in memory stop for repeatable regulation and control. Valves 2 inch and smaller shall have threaded connections and 2-1/2 inch valves shall have flanged connections.

B. Triple Duty Valves: Valve shall be rated for 125 psig working pressure, 300 deg F maximum operating temperature, and shall be cast-iron body with bronze disc and seat, stainless steel stem and spring, and "Teflon" packing. Valves shall have flanged connections and straight or angle pattern as indicated. Features shall include non-slam check valve with spring-loaded weighted disc, and calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.

C. Pressure Reducing Valves: Valve shall be diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.

D. Safety Relief Valves: Valve shall be rated for 125 psig working pressure and 250 deg F maximum operating temperature; designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body

shall be cast-iron, with all wetted internal working parts made of brass and rubber. Select valve to suit actual system pressure and Btu capacity.

E. Combined Pressure/Temperature Relief Valves: Valve shall be diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment. Safety relief valve designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250 deg F maximum operating temperature. Select valve to suit actual system pressure and Btu capacity. Provide with fast fill feature for filling hydronic system.

F. Automatic Flow Control Valves: Valve shall be Class 150, cast iron housing, stainless steel operating parts; threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger. Factory set to automatically control flow rates within plus or minus 5 percent design, while compensating for system operating pressure differential of 2 through 32 psi. Provide quick disconnect valves for flow measuring equipment. Provide a metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and flow rate in GPM.

2.04 HYDRONIC SPECIALTIES

A. Manual Air Vent: Manual air vents at heat transfer coils shall be bronze body and nonferrous internal parts; 150 psig working pressure, 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8 inch discharge and inlet connections. Manual air vents in piping mains shall consist of a tee fitting, 1/2" ball valve, threaded nipple and cap.

B. Automatic Air Vent: Automatic air vents shall be designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 240 deg F operating temperature; and having 1/4 inch discharge connection and 1/2 inch inlet connection.

C. Diverting Fittings: Diverting fittings shall have cast iron body with threaded ends, or wrought copper with solder ends; and shall be rated for 125 psig working pressure, 250 deg F maximum operating temperature. Indicate flow direction on fitting.

D. Y-Pattern Strainers: Strainers shall be rated for 125 psig working pressure and shall have perforated Type 304 stainless steel basket and bottom drain connection. For general piping strainers, screen openings shall be 0.062” perforations for 4” and smaller and 1/8” perforations for larger than 4”. For strainers upstream of automatic flow control valves, screen openings shall be 20 mesh. Strainers, 2” and smaller, shall have cast bronze body (ASTM B-62), threaded connections and screwed cover. Strainers, larger than 2”, shall have cast-iron body (ASTM A 126, Class B), flanged or grooved ends and bolted cover.

E. Basket Strainers:; Strainer shall have high tensile cast-iron body (ASTM A 126, Class B) rated for 125 psig working pressure, flanged end connections, bolted cover, perforated Type 304 stainless steel basket, and bottom drain connection.

F. T-Pattern Strainers:, Strainer shall have ductile iron or malleable iron body rated for 150 psi working pressure, grooved end connections, Type 304 stainless steel strainer basket with 57 percent free area; removable access coupling and end cap for strainer maintenance.

G. Flexible Connectors: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections.

1. Flexible Connectors (Hydronic System equipment connections 4” and larger): Stainless-steel bellows with woven, flexible, stainless steel, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of ¾-inch (20-mm) misalignment.
2. Spherical, Rubber, Flexible Connectors (Hydronic System equipment connections 4” and larger): Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150

and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

3. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors (Hydronic System equipment connections smaller than 4"): Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.
4. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors (Hydronic System equipment connections smaller than 4"): Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.
5. Rubber, Flexible Connectors (Hydronic System equipment connections smaller than 4"): CR or EPDM elastomer rubber construction, with multiple piles of NP fabric, molded and cured in hydraulic presses. Include 125-psig minimum working-pressure rating at 220 deg F. Units may be straight or elbow type, unless otherwise indicated.

H. Combination Piping Packages (Coil/Hose Kits):
1. Combination piping packages are allowed in lieu of individual components specified for hydronic coils and devices containing hydronic coils.
2. Components shall be same size as piping serving the unit as shown on the drawings. Control valves do not need to be same size as piping subject to the sizing requirements set forth in Division 23 "Instrumentation and Control Devices for HVAC."
3. Package shall include the components and shall match layouts specified on the Drawings. Each component of the combination piping package shall meet the specifications for the individual components being combined.

PART 3 - EXECUTION

3.01 VALVE APPLICATIONS

A. General Duty Valve Applications: General duty valve applications are specified in Division 23 Section "Hydronic Piping".

B. Circuit Balancing Valves:
1. Constant Volume Pumping Systems:
a. Install circuit balancing valves where shown on the drawings and elsewhere as required to facilitate system balancing.
2. Variable Volume Pumping Systems:
a. Install circuit balancing valves where shown on the drawings sized for the smaller of the following:
1) Line size.
2) A minimum pressure drop of 1 psi at the design flow rate.

C. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

D. Install check valves on each pump discharge and elsewhere as required to control flow direction.

E. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.

F. Install safety relief valves on hot water generators, and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 1 for installation requirements.

G. Install pressure reducing valves on hot water generators, and elsewhere as required to regulate system pressure.

3.02 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in the system, at heat transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at air separator outlets, expansion tank connections, high points in outlet piping of boilers and hot water heat exchangers and elsewhere as required for system air venting. Pipe outlet of automatic air vents to discharge at floor drains.

C. Install strainers on the supply side of each pressure reducing valve, pressure regulating valve, pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2 inch and larger.

D. On constant volume pumping system, each pumped system shall have a means of balancing the flow. Avoid the use of automatic flow regulating devices. Butterfly valves shall not be used for balancing. Balancing valves shall be specifically manufactured for flow balancing and shall be equipped with pressure measurement taps and shall be provided with flow vs. pressure drop chart. Insure balancing valves are installed with manufacturer's recommended straight lengths of pipe, usually 1.5 to 2 pipe diameters.

E. On variable flow systems, i.e. pumps with VFDs, use a separate check and isolation valve. Balancing or combination valve is not required.

F. Provide inlet strainer, PT plugs, and air vent in piping connection to each coil. Balancing valves are required at each air handler coil but not at individual terminal box reheat coils. Ball shut-off valves on reheat coils shall be provided with memory stops.

G. For AHU's with multiple coils, provide only a single balancing valve to serve the multiple coils. Install with recommended straight pipe lengths before and after balancing valves.

H. Use manual air vents throughout the chilled and hot water heating systems. Avoid use of automatic air vents except where recommended at bladder type expansion tanks.

I. PT test plugs shall be located at each hydronic BAS temperature sensor and at the entering and leaving connections of coils, chillers, hot water boilers and heat exchangers.

J. Contractor to provide facility with a PT measurement kit with thermometers and gages chosen to indicate system pressures and temperatures at mid-scale.

K.

3.03 TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water filtration equipment and/or glycol makeup equipment.

B. Training for Owner's personnel 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.

C. Review manufacturer's safety data sheets for handling of chemicals.

D. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1 and Division 23 Section "General Mechanical Requirements."

E. Schedule at least fourhours of training with Owner, through Architect, with at least seven days' advance notice.

F. 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.

END OF SECTION 23 21 16

SECTION 23 22 16
STEAM AND CONDENSATE PIPING SPECIALTIES

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes steam and condensate piping specialties for low, medium and high pressure steam and condensate piping for building HVAC systems. Materials and equipment specified in this Section include:

1. Piping specialties
2. Special duty valves
3. Steam traps
4. Flash tanks

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

1. Division 23 Section “Expansion Fittings and Loops for HVAC Piping” for materials and methods for providing means of expansion.
2. Division 23 Section "Identification for HVAC Piping & Equipment," for labeling and identification of equipment.
3. Division 23 Section "Common Work Results for HVAC" for materials and methods for equipment pads.
4. Division 23 Section "Basic Piping Material and Methods," for materials and methods for flexible connectors and mechanical sleeve seals.
5. Division 23 Section "General Duty Valves for HVAC Piping," for materials and methods for installing steam and condensate piping valves.
6. Division 23 Section "Hangers & Supports for HVAC Piping & Equipment," for insulation shields, saddles and materials and methods for hanging and supporting steam and condensate piping specialties.
7. Division 23 Section "HVAC Insulation," for materials and methods for insulating steam and condensate piping specialties.
8. Division 23 Section “Hydronic Piping” for dielectric unions, waterway fittings and flanges.

1.02 DEFINITIONS

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

B. Low Pressure Steam Systems operate at 15 psig (100 kPa above atmospheric) and under.

C. Medium Pressure Steam Systems operate between 15 psig (100 kPa above atmospheric) and 60 psig (414 kPa above atmospheric).

D. High Pressure Steam Systems between 60 psig (414 kPa above atmospheric) and 125 psig (861 kPa above atmospheric).

1.03 SUBMITTALS

A. Product data, including rated capacities where applicable, furnished options and accessories, and installation instructions for:

1. Safety Relief Valves.
2. Pressure Reducing Valves.

3. Steam Traps, including recommended safety factor sizing information.
4. Thermostatic Air Vents.
5. Strainers.
6. Vacuum Breakers.
7. Metal Flexible Connectors.
8. Flash Tanks

B. Shop drawings, detailing dimensions, methods of assembly of components, and location and size of each field connection for steam and condensate specialties.

C. Maintenance data, including data for steam and condensate specialties and special duty valves. Refer to Division 1 and Division 23 Section "General Mechanical Requirements" for detailed requirements.

D. Welders' certificates certifying that welders comply meet the quality requirements specified in Quality Assurance below.

E. Certification of compliance with specified ASTM, ASME, and ANSI manufacturing requirements for piping specialties.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: comply with the provisions of the following:

1. ASME B 31.9 "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 Qualification" for qualifications for welding processes and operators.

B. Piping 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

2.01 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide steam and condensate piping system products from one of the following:

1. Safety Pressure Relief Valves:
   a. Armstrong International
   b. Kunkle Valve Co., Inc.
   c. Spence Engineering
   d. Spirax Sarco.
   e. Watts Regulator Co.
2. Pressure Reducing Valves:
   a. Hoffman Specialty ITT; Fluid Handling Div.
   b. Leslie Controls
   c. Spirax Sarco.
3. Steam Traps:

a. ITT Hoffman
b. Spirax Sarco.
c. Watson McDaniel

4. Thermostatic Air Vents:
   a. Hoffman Specialty ITT; Fluid Handling Div.
   b. Spirax Sarco.
5. Strainers:
   a. Hoffman Specialty ITT; Fluid Handling Div.
   b. Spirax Sarco.
6. Metal Flexible Connectors:
   a. Hyspan Precision Products
   b. Mason Industries, Inc.
   c. Metraflex Co.
   d. Proco Products, Inc.
   e. Duraflex
   f. Flexicraft Industries
7. Vacuum Breakers
   a. Armstrong International
   b. ITT Hoffman
   c. Spirax Sarco
8. Flash Tanks:
   a. Armstrong International
   b. Penn Separator Corporation.
   c. Precision Boilers.
   d. Wendland Manufacturing Co.

2.02 SPECIAL DUTY VALVES

A. Special duty valves are specified in this Article by their generic name; refer to Part 3 below, Article "VALVE APPLICATION" for specific uses and applications for each valve specified.

2.03 SAFETY RELIEF VALVES

A. General: Select steam safety valves for full relief of capacity of equipment served, in accordance with ASME Boiler and Pressure Vessel Code. Furnish complete with cast iron drip-pan elbow having threaded inlet and outlet with threads (FPT) conforming to ANSI B1.20.1; sized for full size of safety valve outlet connection.

B. Bronze Safety Valves: Valve shall have Class 250 cast bronze body with threaded (MPT) inlet and threaded (FPT) outlet; forged copper alloy disc, fully enclosed cadmium plated steel spring having an adjustable pressure range and positive shut-off. Factory-set valves to relieve at 10 psi above operating pressure.

C. Cast-Iron Safety Valves: Valve shall have Class 250 cast iron body and bronze seat, forged copper alloy disc and nozzle; fully enclosed stainless steel spring having an adjustable pressure

range and positive shut-off; threaded end connections for valves 2 inch and smaller, raised face flanged inlet and threaded outlet connections for valves 2-1/2 inch and larger. Factory-set valves to relieve at 10 psi above operating pressure.

2.04 PRESSURE REDUCING VALVES

A. General: Select pressure reducing valves of size, capacity, and pressure rating as scheduled. Factory-set for inlet and outlet pressures as indicated.

B. Valves Characteristics: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shut-off; cast iron body with flanged end connections for 2 1/2-inches and larger and threaded end connections for 2-inches and smaller, hardened stainless steel trim, and replaceable valve head and seat.

2.05 BACK PRESSURE REGULATING VALVES

A. General: Select back pressure regulating valves of size, capacity, inlet (upstream) pressure, pressure drop, pressure rating, and operating temperature. Valves shall be factory-set for inlet and outlet pressures as indicated.

B. Valve Characteristics: Pilot actuated, diaphragm type with adjustable pressure range and positive shutoff; cast iron body with flanged end connections; stainless steel seats, discs and stems; steel spring; non-asbestos gasket; normally closed operation; and +/- 1 psig accuracy.

C. Manufacturer:

1. Spence Engineering Co., model E5Q
2. Approved equal.

2.06 STEAM TRAPS

A. General: Size steam traps for the load served including manufacturer’s recommended safety factors for the application and location except when a safety factor is specified on the drawings. Include manufacturer’s recommended safety factor sizing information in the steam trap submittal.

B. Thermostatic Traps: Trap shall have cast brass, angle pattern body, with integral union tailpiece and screw-in cap; maximum operating pressure of 25 psig; balanced pressure stainless steel or Monel diaphragm or bellows element, with renewable hardened stainless steel valve head and seat.

C. Float and Thermostatic Traps (below 15 psig): Trap shall have ASTM A 48 or A 126, Class 30 cast iron body and bolted cap; renewable, stainless steel float mechanism, with renewable, hardened stainless steel head and seat; balanced pressure thermostatic air vent made of stainless steel or Monel bellows with stainless steel head and seat. Capacity as indicated on the plans with 0.5 psi differential pressure.

D. Float and Thermostatic Traps (15 psig and higher): Trap shall have ASTM A 48, cast iron body and bolted cap; maximum design pressure of 175 psig; renewable, stainless steel float mechanism, with renewable, hardened stainless steel head and seat; balanced pressure thermostatic air vent made of stainless steel capable of operation with 45 degree F superheat. Provide with integral vacuum breaker. Capacity as indicated on the plans with differential pressure at one half operating pressure.

E. Inverted Bucket Traps: Trap shall have ASTM A 48 or A 126, Class 30 cast iron body and cap, pressure rated for 250 psi; stainless steel head and seat; stainless steel valve retainer, lever, guide pin assembly, brass or stainless steel bucket.

1. Provide integral stainless steel inlet strainer within trap body if strainer is not provided in the inlet piping to the trap.

2.07 THERMOSTATIC AIR VENTS

A. Quick Vents: Vent shall have cast iron or brass body, with balanced pressure stainless steel or Monel thermostatic bellows, and stainless steel heads and seats.

B. Float Vents: Vent shall have cast iron or brass body; seamless stainless steel float; balance pressure thermostatic bellows; replaceable stainless steel seat, float, and head.

2.08 STRAINERS

A. Y-Pattern Strainers:

1. Pressure Class:Minimum 125 psig.
2. Construction: Cast iron body conforming to ASTM A 126.
3. End Connection: Threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger.
4. Accessories:
    a. Grade 18-8 stainless steel screen:
        1) 0.045 inch perforations for 10 inch and smaller.
        2) 0.062 inch perforations for sizes 12 inch and larger.
    b. Tapped blow-off plug.

B. Basket Strainers:

1. Pressure Class: Minimum 125 psig.
2. Construction: Cast iron body conforming to ASTM A 126.
3. End Connection: Flanged.
4. Accessories:
    a. Grade 18-8 stainless steel screen.
    b. Bolted cover.

2.09 FLEXIBLE CONNECTORS

A. Flexible Connectors (Steam System equipment connections 4” and larger): Stainless-steel bellows with woven, flexible, stainless steel, wire-reinforcing protective jacket; minimum working pressure and maximum operating temperature compatible with steam or condensate operating conditions. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of ¾-inch (20-mm) misalignment.

B. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors (Steam System equipment connections smaller than 4”): Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose. Minimum working pressure and maximum operating temperature shall be compatible with steam or condensate operating conditions.

2.10 FLASH TANKS

A. Construct flash tanks of welded steel in accordance with ASME Boiler and Pressure Vessel Code, for 150 psig rating. Fabricate all welds and tappings for vents, steam and condensate outlets of pressure indicated on the drawings, high pressure condensate inlet, air vent, safety valve, and legs prior to application of ASME label.

2.11 VACUUM BREAKERS

A. Cast iron, bronze or stainless steel body with threaded connections; stainless steel sealing ball, retainer spring and screen; EPR O-ring seal; and pressure and temperature ratings of 125 psig and 350 degrees F.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.02 PIPING SPECIALTY INSTALLATIONS

A. Install flexible connectors at inlet and discharge connections to pumps and other vibration producing equipment as indicated.

B. Install strainers on the supply side of each control valve, pressure regulating valve, solenoid valve, traps, and elsewhere as indicated. Install strainers in the horizontal position. Install 3/4 inch NPS nipple and ball valve in blow down connection of strainers 2 inch and larger. Use same size nipple and valve as blow-off connection of strainer.

C. Install steam traps close to drip legs.

D. Flash Tanks: Pitch condensate lines towards flash tank. If more than one condensate line discharges into flash tank, install a swing check valve in each line. Install a thermostatic air vent at the top of the tank. Install an inverted bucket or float and thermostatic trap at the low pressure condensate outlet, sized for triple the condensate load. Install a safety relief valve at the tank top. Install a pressure gage, gate valve, and swing check valve on the low pressure (flash) steam outlet.

3.03 HANGERS AND SUPPORTS

A. Hanger, supports, and anchors devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

3.04 STEAM TRAP INSTALLATIONS

A. Install steam traps in accessible locations as close as possible to connected equipment. Maximum allowable distance from equipment is 4 feet.

1. Unless otherwise indicated, install gate valve (or full-port ball valve for low pressure steam and condensate), strainer, and union upstream from the trap; install union, check valve, and gate valve downstream from trap.

3.05 PRESSURE REDUCING VALVE INSTALLATIONS

A. General: Install pressure reducing valves as required to regulate system pressure. Install in a location readily accessible for maintenance and inspection.

B. Size reducing valves to supply the maximum steam requirements of the heating system or equipment indicated, at the indicated inlet and outlet pressures.

C. Provide bypass around each reducing valve, with a globe valve equal in size to the area of the reducing valve seat ring.

D. Install gate valves and unions around each reducing valve to facilitate removal and repair of reducing valves. Unions may be omitted for reducing valves with flanged connections.

E. Install pressure gages on the low pressure side of each reducing valve and ahead of the shutoff valve plus one downstream for the shutoff valve.

1. On two-stage reducing stations, install a drip trap and pressure gage upstream from the second stage reducing valve.

F. Install strainers upstream of each reducing valve.

1. On two-stage reducing stations omit the strainer upstream from the second stage, unless specifically indicated otherwise.

G. Install safety valves downstream from each reducing valve set at 10 psig higher than the reduced pressure.

3.06 SAFETY VALVE INSTALLATIONS

A. Install relief valves in accordance with and where required by ASME B 31.1 - "Power Piping." Pipe discharge to atmosphere outside the building, without stop valves. Terminate vent pipe with screened vent cap. Install a drip pan elbow fitting adjacent to the safety valve. Pipe drip pan elbow drain connection to the nearest floor drain without valves. Comply with ASME Boiler and Pressure Vessel Code for installation requirements.

3.07 TERMINAL HEATING AND COOLING EQUIPMENT CONNECTIONS

A. Install vacuum breaker downstream from the control valve and bypass, and as close as possible to the coil inlet connection.

END OF SECTION 23 22 16

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes:

1. Rectangular, round, and flat-oval metal ducts and plenums for heating, ventilating, and air conditioning systems in pressure classes from minus 2 inches to plus 10 inches water gauge.
2. Duct liner.
3. Factory-fabricated grease exhaust ductwork.
4. Wire rope hanging system.

B. Related Sections:

1. Division 7 Section "Penetrations Firestopping," for materials and methods for fire barrier penetrations.
2. Division 7 Section "Joint Sealers," for materials and methods for sealing duct penetrations through basement and foundation walls.
3. Division 23 Section "Identification for HVAC Piping & Equipment," for labeling and identification of metal ducts.
4. Division 23 Section "Common Work Results for HVAC," for materials and methods for wall penetrations and equipment pads.

1.02 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.

1.03 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.

1.04 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.

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.

1.05 QUALITY ASSURANCE

A. 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."

B. Qualify each welder in accordance with AWS qualification tests for welding processes involved. Certify that their qualification is current.

C. 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.

D. 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.

E. 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.

F. National Air Duct Cleaners Association, Inc. (NADCA): Clean ductwork systems in accordance with the standard Assessment, Cleaning and Restoration of HVAC Systems (ACR 2002).

1.06 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. Replace duct liner that has gotten wet during shipping, storage or installation. Dry surfaces prior to installing new duct liner.

PART 2 - PRODUCTS AND MATERIALS

2.01 SHEET METAL MATERIALS

A. Sheet Metal, General: Provide sheet metal in thickness indicated (minimum 24 gauge), packaged and marked as specified in ASTM A 700.

B. Galvanized Sheet Steel: Lock-forming quality, ASTM A 653, Coating Designation G 90. Provide mill phosphatized or galvanealed 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. PVC-Coated Galvanized Steel: UL-181 Class 1 Listing. Lock-forming quality galvanized sheet steel with ASTM A 653, Coating Designation G 90. Provide with factory-applied, 4-mil, PVC coating on the exposed surfaces of ducts and fittings (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.

D. Carbon Steel Sheets: ASTM A 366, cold-rolled sheets, commercial quality, with oiled, exposed matte finish.

E. Stainless Steel: ASTM A 480, Type 316, sheet form, with No. 4 finish on exposed surface for ducts exposed to view; Type 304, sheet form, with No. 1 finish for concealed ducts.

F. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form; with standard, one-side bright finish where ducts are exposed to view, and mill finish for concealed ducts.

G. 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.

H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 SEALING MATERIALS

A. Joint and Seam Sealants, General: Duct tape shall not be used as a sealant on any ducts.

B. Water-Based Joint and Seam Sealant, Non-Fibrated: UL 181 Listed and UL 723 classified with flame spread/smoke development of less than 25/50. 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 32-19, United Duct Sealer (Water Based) and Hardcast 601.

2.03 FIRE-STOPPING

A. Fire-Resistant Sealant: Provide 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.

B. Fire-Resistant Sealant: Provide 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.

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

1. "3M Fire Stop Foam"; 3M Corp.
2. "SPECSEAL Pensil 200 Silicone Foam"; Specify Technology, Inc.
3. 3M Fire Stop Sealant"; 3M Corp.
4. "3M Fire Barrier Caulk CP-25"; Electrical Products Div./3M.
5. "Fyre Putty"; Standard Oil Engineered Materials Co.
6. “FS-ONE”, Hilti, Inc.

2.04 HANGERS AND SUPPORTS

A. 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.

B. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.

1. Hangers Installed In Corrosive Atmospheres: Electro-galvanized, all-thread rod or hot-dipped-galvanized rods with threads painted after installation.
2. Straps and Rod Sizes: Conform with SMACNA HVAC Duct Construction Standards, 2005 Edition, for sheet steel width and gauge and steel rod diameters.

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

D. Trapeze and Riser Supports: Steel shapes conforming to ASTM A 36.

1. Where galvanized steel ducts are installed, provide hot-dipped-galvanized steel shapes and plates.
2. For stainless steel ducts, provide stainless steel support materials.
3. For aluminum ducts, provide aluminum support materials, except where materials are electrolytically separated from ductwork.

2.05 RECTANGULAR DUCT FABRICATION

A. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Tables 2-1 through 2-28, including their associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.

1. Fabricate rectangular ductwork of minimum 24 gauge sheet metal.

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

3. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

B. 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.

C. 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”.

D. Field Painted Ductwork: Provide mill phosphatized finish on exposed surfaces of rectangular ductwork and duct fittings to be field painted.

2.06 RECTANGULAR DUCT FITTINGS

A. 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.

B. 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.

C. 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.

D. Provide full radius elbows for ductwork installed in noise critical spaces. Refer to Section “Basic Mechanical Materials and Methods” for noise critical spaces. Where space does not permit the installation of radius elbows, provide mitered elbows with sound attenuating, acoustical turning vanes. Refer to Section “Ductwork Accessories” for acoustical turning vanes.

2.07 ROUND AND FLAT OVAL DUCT FABRICATION

A. 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.

1. Fabricate round and flat oval ductwork of minimum 24 gauge sheet metal.

B. 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.

C. Flat Oval Ducts: Fabricate flat oval supply ducts with standard spiral lockseams (without intermediate ribs) or with butt-welded longitudinal seams in gauges listed in SMACNA "HVAC Duct Construction Standards," 2005 Edition, Table 3-15.

D. Field Painted Ductwork: All round and flat oval ductwork and duct fittings to be field painted shall have galvanized metal primer applied in the shop after fabrication and prior to shipping.

2.08 ROUND AND FLAT OVAL SUPPLY AND EXHAUST FITTINGS FABRICATION

A. 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.

B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from the body onto branch tap entrance.

C. Elbows: 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. 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. 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. Unless elbow construction type is indicated, provide elbows meeting the following requirements:

1. Mitered Elbows: Fabricate mitered elbows with welded construction in gauges specified below.

a. 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.

b. Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from minus 2 inches to plus 2 inches:

1) 3 to 26 inches: 24 gauge.

2) 27 to 36 inches: 22 gauge.

3) 37 to 50 inches: 20 gauge.

4) 52 to 60 inches: 18 gauge.

5) 62 to 84 inches: 16 gauge.

c. Round Mitered Elbows: Solid welded and with metal thickness listed below for pressure classes from 2 inches to 10 inches:

1) 3 to 14 inches: 24 gauge.

2) 15 to 26 inches: 22 gauge.

3) 27 to 50 inches: 20 gauge.

4) 52 to 60 inches: 18 gauge.

5) 62 to 84 inches: 16 gauge.

d. Flat Oval Mitered Elbows: Solid welded and with the same metal thickness as longitudinal seam flat oval duct.

e. 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.

2. 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.

3. 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.

4. Round Elbows - Larger Than 14 Inches and All Flat Oval Elbows: Gored elbows, except where space restrictions require a mitered elbow.

5. Die-Formed Elbows for Sizes Through 8 Inches and All Pressures: 20 gauge with 2-piece welded construction.

6. Round Gored Elbows Gauges: Same as for non-elbow fittings specified above.

7. Flat Oval Elbows Gauges: Same as longitudinal seam flat oval duct.

8. Pleated Elbows Sizes Through 14 Inches and Pressures Through 10 Inches: 24 gauge.

2.09 FACTORY-MANUFACTURED DUCTWORK

A. General: At the Contractor’s option, factory-manufactured ductwork can be provided instead of fabricated ductwork for round and oval ductwork. All factory-manufactured round and oval supply, return and exhaust ductwork shall be Linx Industries, Inc Lindab Safe, Lewis & Lambert, Wesco or approved equal. 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 in this section.

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 thickness as shown in the following tables:

Single Wall Round Duct:

Diameter (Inches)	Galvanized Spiral Duct	Galvanized Fittings

3-14	24	24
15-24	24	24
26-42	24	22
42-60	22	20

Double Wall Round Duct:

Diameter (Inches)	Galvanized Spiral Duct		Galvanized Fittings	
	Inner	Outer	Inner	Outer
3-14	28	24	24	24
16-24	26	24	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. All duct 14" diameter and larger shall be corrugated for added strength and rigidity.
4. Spiral seam slippage shall be prevented by means of a flat seam and a mechanically formed indentation evenly spaced along the spiral seam.
5. Ducts shall be constructed using spiral lock seam sheet metal construction.
6. Ductwork to be installed in exposed locations shall have the surface prepared in the factory for field painting.

C. Fittings:

1. All fitting ends for round duct and transitions and divided flow fittings smaller than 50” 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 insure 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 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 lb/ft3 (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 Lindab Safe 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 approved equal. Damper shall be fitting sized to slip into spiral duct. 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.

PART 3 - EXECUTION

3.01 DUCT MATERIAL APPLICATION

A. All ducts shall be galvanized steel except as follows:

1. Grease Hood Exhaust Ducts: Comply with NFPA 96.
    a. Concealed: Carbon-steel sheet, minimum 16 gauge.
    b. Exposed: Type 304, stainless steel, minimum 18 gauge, with finish to match kitchen equipment and range hood.
    c. Weld and flange seams and joints.
    d. At Contractor's option, a UL listed concentric ductwork package may be used in lieu of the welded carbon steel duct for connecting hood to exhaust fan. Provide manufacturers UL listing number and verification certificate as a part of the shop drawing submittal. Install duct package in strict conformance with manufacturer's instructions and recommendations.

2. Dishwasher Hood Exhaust Ducts:
    a. Dishwasher exhaust duct shall be continuously welded aluminum above the ceiling and welded stainless steel below the ceiling or continuously welded stainless steel.
    b. Slope ductwork serving dishwasher hood to drain back to hood. Provide condensate drains as required to prevent the accumulation of water within ductwork.

3. Dryer Vent Ducts: Rigid, smooth wall, aluminum duct, minimum 24 gauge.
4.

3.02 DUCT INSTALLATION, GENERAL

A. Duct System Pressure Class: Construct and install each duct system except factory-manufactured ductwork for the specific duct pressure classification indicated. For factory-manufactured ductwork, refer to Paragraph “Factory-Manufactured Ductwork”.
    1. Supply Air Ducts: 3 inches water gauge.
    2. Primary Supply Air Ducts (upstream of terminal boxes): 4 inches water gauge.
    3. Secondary Supply Air Ducts (downstream of terminal boxes): 2 inches water gauge
    4. Return and Outdoor Air Ducts: 2 inches water gauge, negative pressure(3” pressure class for 100’from fan).
    5. Exhaust Air Ducts: 2 inches water gauge, negative pressure.

B. Install ducts with the fewest possible joints.

C. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

D. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

E. 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.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. 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.

H. Provide clearance of 1 inch where furring is shown for enclosure or concealment of ducts, plus allowance for insulation thickness, if any.

I. Install insulated ducts with 1-inch clearance outside of insulation.

J. 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.

K. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

L. 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.

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

N. 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.

O. Acoustical Barrier Penetrations: Where a duct passes through a wall, ceiling or floor slab of a noise critical space, provide a clear annular space of 1-inch between the duct and the structure. Refer to Section “Common Work Results for HVAC” for noise critical spaces. The Contractor shall check the clearance and, if clearance is acceptable, shall install the duct and pack the voids full depth with mineral fiber batt insulation. Contractor shall caulk both ends with a non-aging, non-hardening sealant backed by a polyethylene foam rod or permanently flexible firestop material. Where there is insufficient clearance space, Contractor shall place a short stub duct in the wall, pack and caulk around it and then attach the inlet and outlet ducts to each end.

3.03 SEAM AND JOINT SEALING

A. General: Seal duct seams and joints as follows:

1. All ductwork, including supply, return and exhaust shall have circumferential joints, longitudinal joints, and duct wall penetrations externally sealed in accordance to SMACNA Class A. The sealant used to seal the longitudinal joints of low pressure ductwork must be visible or the joints shall require resealing in the field.

2. Seal class shall apply to all supply, return, outdoor air, and exhaust ductwork, regardless if the duct is positively or negatively pressurized.

B. Seal externally insulated ducts prior to insulation installation.

C. 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.

3.04 HANGING AND SUPPORTING

A. Install rigid round, rectangular, and flat oval metal duct with support systems indicated in Chapter 5 of the SMACNA "HVAC Duct Construction Standards", 2005 Edition.

B. The use of wire rope hanging systems is an acceptable alternate hanging methods 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.

C. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

D. Support vertical ducts at a maximum interval of 16 feet and at each floor.

E. 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.

F. Install concrete insert prior to placing concrete.

G. Install powder actuated concrete fasteners after concrete is placed and completely cured.

3.05 PENETRATIONS

A. Fire Barrier Penetrations: Where ducts pass though fire-rated walls, partitions, ceilings, and floors, maintain the fire-rated integrity.

B. Exterior Wall Penetrations: Seal duct penetrations through exterior wall constructions with sleeves, packing, and sealant. Refer to Division 23 Section “Basic Mechanical Materials and Methods” for additional information.

C. Underground Exterior Wall Penetrations: Seal duct penetrations through underground exterior walls with sleeves, packing, and sealant. Refer to Division 23 Section “Basic Piping Materials and Methods” for additional information.

D. 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 Mechanical Materials and Methods” for special sealers and materials.

3.06 CONNECTIONS

A. Equipment Connections: Connect equipment with flexible connectors in accordance with Division 23 Section "Air Duct Accessories."

B. Branch Connections: Comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figures 4-5 and 4-6.

C. Outlet and Inlet Connections: Comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figures 7-6 and 7-7. 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. Fan Connections: Comply with SMACNA "HVAC Duct Construction Standards," 2005 Edition, Figure 7-8.

3.07 FIELD QUALITY CONTROL

A. Refer to Paragraph “Field Constructed Mock-Ups” in Part 1 for duct systems to be leak tested.

B. The Owner will contract with an independent testing agency to perform, record, and report leakage tests.

C. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.

D. All duct shall be cleaned and capped prior to installing and installed duct shall not have the ends uncapped to prevent the entry of dust during construction.

3.08 FIELD QUALITY CONTROL

A. Duct Leakage Testing:

1. Perform leak testing for all ductwork with a pressure classification of 2″ and above, ductwork with a cross-sectional area greater than 6 square feet, and all ductwork enclosed in shafts.

2. Leak test at least 50% of the low pressure supply, and 50% of the return and exhaust ductwork to ensure duct tightness and air handler system performance. Leak test the supply duct from the AHU to the terminal boxes. Leak test return and exhaust duct that is the equivalent of 8 inches in diameter and larger. Leak test all duct that is an enclosed in a chase or above a drywall ceiling.

3. Follow procedure published by United Sheet Metal Division of United McGill Corporation entitled “System Pressure Testing for Leaks” using prescribed test kit containing test blower, two U-tube manometer, and calibrated orifice tube. Orifice flow measurement device to be individually calibrated against a primary standard and a calibrated curve permanently attached to orifice tube assembly.

4. If system is tested in sections, leakage rates may be totaled to give performance of the whole system.

5. All leak testing is to be witnessed by General Contractor's Quality Control on-site representative. Require the General Contractor to maintain, on-site, a set of ductwork prints that are shaded in different colors to show the duct sections isolated for each test. Specify that the General Contractor shall also indicate on the print, the date each section of duct was tested and the final percent leakage rate measured for each test section.
6. The final duct leakage test report is to be submitted to the Commissioning Authority.
7. For low pressure ductwork,where both longitudinal and transverse seams are fully sealed, leakage test described herein may be omitted.

B. Grease Duct Leakage Test: All portions of grease duct systems shall be tested for leakage in accordance with Chapter 5, Section 506 of the locally adopted IMC. Leakage tests shall be by light or other equivalent test methods as approved by the local code official to verify that all joints are liquid tight. Tests shall be performed in the presence of the local code official. Any joints found defective shall be repaired and retested until satisfactory results are obtained. The contractor shall submit a copy of the grease duct leakage test report to the Architect and Engineer complete with the approval signature of the local code official.

C. Smoke Control Duct Leakage Test: All portions of smoke control duct systems shall be tested for leakage in accordance with Chapter 5, Section 513 of the locally adopted IMC. Ducts shall be leak tested to 1.5 times the maximum design pressure. Measured leakage shall not exceed 5 percent of design air flow. Test shall be as approved by the local code official to verify that all joints are liquid tight. Tests shall be performed in the presence of the local code official. Any joints found defective shall be repaired and retested until satisfactory results are obtained. The contractor shall submit a copy of the smoke control duct leakage test report to the Architect and Engineer complete with the approval signature of the local code official.

3.09 ADJUSTING 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.

END OF SECTION 23 31 13

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. Extent of ductwork accessories work is indicated on drawings and in schedules, and by requirements of this Section.

B. Types of ductwork accessories required for project include the following:

1. Dampers.
    a. Low pressure manual dampers.
    b. Counterbalanced backdraft dampers.
2. Electronic zone pulse damper systems.
3. Turning vanes.
4. Duct hardware.
5. Duct access doors.
6. Flexible ductwork.
7. Flexible elbow assembly.
8. Metal duct connectors.
9. Flexible duct connectors.

C. Refer to other Division 23 Sections for testing, adjusting, and balancing of ductwork accessories; not work of this Section.

1.02 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:

1. SMACNA Compliance: Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible", 2005 Edition.
2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
3. UL Compliance:
    a. Construct, test, and label fire dampers in accordance with current edition of UL Standard 555 "Fire Dampers". Construct, test, and label smoke dampers in accordance with current edition of UL Standard 555S "Smoke Dampers".
    b. Construct flexible ductwork in compliance with UL Standard 181 “Factory-Made Air Ducts and Connections”.
    c. Duct tape shall be labeled in accordance with UL Standard 181B and marked 181B-FX. Non-metallic duct clamps shall be labeled in accordance with UL Standard 181B and marked 181B-C.
    d. Duct clamps shall be labeled in accordance with UL Standard 181B and marked 181B-C.
    e. Grease exhaust duct wrap shall meet the fire protection requirements defined by UL Standard 1479 “Fire Tests of Through-Penetration Firestops.”.
    f. Fire rated duct wrap shall meet the fire protection requirements defined by UL Standard 1479 “Fire Tests of Through-Penetration Firestops.”.
4. NFPA Compliance:

a. Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories. Comply with NFPA 90B “Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

b. Comply with NFPA 96 “Ventilation Control and Fire Protection of Commercial Cooking Operations” for fire-rated grease exhaust ducts.

5. 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.

a. Duct silencers shall be tested for performance in accordance with ASTM E477 “Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.”

b. Grease exhaust duct wrap shall be tested for performance in accordance with ASTM E 2336 “Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems” and ASTM E814 “Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops”.

c. Fire rated duct wrap shall be tested in accordance with ASTM E814 “Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops”.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory including dimensions, capacities and materials of construction; and installation instructions. 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.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.

C. 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; in accordance with requirements of Division 1.

1.04 SPARE PARTS

A. Furnish extra fusible links to Owner, one link for every 10 installed of each temperature range; obtain receipt.

PART 2 - PRODUCTS AND MATERIALS

2.01 DAMPERS

A. Low Pressure Manual Dampers: Provide dampers of single blade type or multi-blade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards". Damper material shall be galvanized steel for standard air systems, aluminum for wet or natatorium environments and stainless steel for corrosive environments. Bearings shall be corrosion resistant, molded synthetic and axles shall positively lock into the damper blade. Extended shafts shall be metal material. Blade seals shall be neoprene for round dampers. Blade seals shall be silicone for rectangular dampers. Dampers shall be Greenheck Model MBD Series, or approved equal, with locking quadrant. Provide with standoff bracket and shaft extension as required for insulation requirements.

B. Control Dampers: Refer to Division 23 section Instrumentation and Control Devices for HVAC for control dampers; not work of this section.

C. Counterbalanced Backdraft Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to open at indicated static pressure. Construct frames and blades of minimum 16-ga aluminum. Provide minimum 1/2" diameter, corrosion-resistant bearings and 1/2" diameter, galvanized or stainless steel axles. Blade edge seals shall be mechanically locked

into blade edge. Blade seals shall be neoprene for round dampers. Blade seals shall be silicone or vinyl for rectangular dampers.

D. Manufacturer: Subject to compliance with requirements, provide dampers of one of the following:
   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

2.02 CABLE OPERATED DAMPER SYSTEMS

A. General: Where access to dampers through a hard ceiling is required, provide a concealed, cable operated volume damper with remote operator.
   1. Damper shall be adjustable through the diffuser face or frame with standard 1/4” nutdriver or flat screwdriver.
   2. Cable assembly shall attach to damper as one piece with no linkage adjustment.
   3. Positive, direct, two-way damper control shall be provided with no sleeves, springs or screw adjustments to come loose after installation.
   4. Provide cable length as required to span the distance from the damper to the remote operator location.
   5. Support cable assembly to avoid bends and kinks in cable.

B. Manufacturer: Subject to compliance with requirements, provide cable operated damper systems of one of the following:
   1. Metropolitan Air Technology, Inc. (Reference model number is RT-250).
   2. Young Regulator Co..

2.03 TURNING VANES

A. 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. Vanes shall be rigidly fastened with guide strips to minimize noise and vibration. Vanes in ductwork over 30" deep shall be installed in multiple sections with vanes not over 30" long and shall be rigidly fastened. 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.

B. 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”.

C. Manufacturer: Subject to compliance with requirements, provide turning vanes of one of the following:
   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.

2.04 DUCT HARDWARE

A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
   1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
   2. 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.

B. Manufacturer: Subject to compliance with requirements, provide duct hardware of one of the following:
   1. Ductmate Industries.
   2. Elgen Manufacturing Co., Inc.
   3. Ventfabrics, Inc.
   4. Young Regulator Co.

2.05 DUCT ACCESS DOORS

A. General: 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”. Provide removable section of duct where duct size is too small for a 10” by 10” access door. Construct access doors in accordance with SMACNA “HVAC Duct Construction Standards – Metal and Flexible” and as specified herein. Label access doors for fire and smoke dampers as specified in Paragraph “Installation of Ductwork Accessories.

B. Construction: Construct of same or greater gage as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one size hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

C. Manufacturer: Subject to compliance with requirements, provide duct access doors of one of the following:
   1. Air Balance Inc.
   2. Ductmate Industries.
   3. Duro Dyne Corp.
   4. Register & Grille Mfg. Co., Inc.
   5. Ruskin Mfg. Co.
   6. Ventifabrics, Inc.
   7. Vent Products.
   8. Zurn Industries, Inc.; Air Systems Div.

2.06 FLEXIBLE DUCT.

A. 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 regards to required quality of construction and materials. Flexible duct shall have fire retardant polyethylene or reinforced metalized protective vapor barrier as follows:
   1. Low pressure (duct pressure class up to and including 2” w.g.) and medium pressure (duct pressure class greater than 2” 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. High pressure (duct pressure class over 6" w.g.)
a. Fire retardant polyethylene vapor barrier
1) Flexmaster Type 3B

b. Reinforced metalized vapor barrier
1) Flexmaster Type 3M
2) Thermaflex Type M-KC

3. Flexible ductwork shall have CPE liner with steel wire helix mechanically locked or permanently bonded to the liner.
4. Provide acoustical, fiberglass insulated duct with minimum R-value of [R-4.2][R-5.0][R-6.0][R-8.0].

B. Manufacturer: Subject to compliance with requirements, provide flexible ductwork of one of the following:
1. ATCO Rubber Products.
2. Flexmaster.
3. JPL (J.P. Lamborn Co)
4. Thermaflex.

2.07 FLEXIBLE ELBOW ASSEMBLY

A. General: At Contractors option, in lieu of rigid sheet metal elbows at connections to air inlets and outlets in concealed spaces, provide flexible elbow assembly to air devices requiring a 90 degree elbow connection.

B. Flexible elbow assembly shall be constructed of durable composite material and UL listed for use in return air plenums with a turning radius of not less than 3 inches.

C. Flexible elbow assembly shall be FlexFlow Elbow as manufactured by Flexible Technologies, Inc., FlexRight Elbow as manufactured by Build Right Products or approved equal.

2.08 METAL DUCT CONNECTORS

A. Description: Factory-fabricated, slide-on transverse flange connectors, corners, cleats, gaskets, and components. Material, gauge, and shape shall match the connecting ductwork.

B. Manufacturers: Subject to compliance with requirements, provide duct connectors by one of the following or approved equal:
1. Ductmate Industries.
2. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

2.09 FLEXIBLE DUCT CONNECTORS

A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of fabric crimped into duct flanges for attachment to duct and equipment. 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.

B. Fabric Material: Flame-retardant or noncombustible fabrics compliant with NFPA 701.

1. Metal-Edged Connectors: 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 sheets. Provide metal compatible with connected ducts.
2. Indoor System, Flexible Connector Fabric: Glass fabric coated with neoprene.
    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.
3. Outdoor System, Flexible Connector Fabric: Glass fabric coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
    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.
4. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
    a. Minimum Weight: 16 oz./sq. yd.
    b. Minimum Tensile Strength: 200 lbf/inch in the warp and 150 lbf/inch in the filling.
    c. Service Temperature: Minus 65 to plus 500 deg F.
5. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
    a. Minimum Weight: 14 oz./sq. yd.
    b. Minimum Tensile Strength: 400 lbf/inch in the warp and 300 lbf/inch in the filling.
    c. Service Temperature: Minus 67 to plus 500 deg F.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. 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.

E. Manufacturer: Subject to compliance with requirements, provide flexible connections of one of the following:
1. Ductmate Industries.
2. Duro Dyne Corp.
3. Elgen Manufacturing Co., Inc.
4. Ventfabrics, Inc.

PART 3 - EXECUTION

3.01 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.

3.02 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. Install [backdraft] [control] dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

C. Provide balancing 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 balancing damper and locking quadrant for branch duct connections and take-offs to individual diffusers, registers and grilles.

D. Coordinate all smoke and fire/smoke damper installation, wiring, and checkout to ensure that the dampers function properly and that they respond to the proper fire alarm system signal.

E. Install ceiling radiation dampers per manufacturer's instructions. Support damper assembly from structure.

F. Provide turning vanes, of same gauge as ductwork, rigidly fastened with guide strips in ductwork having an offset of 45 degrees or more. Vanes 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.

G. 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, and equipment at the following locations: 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. At each change in direction and at maximum 50-foot (15-m) spacing.
2. Upstream [and downstream] from turning vanes.
3. Upstream or downstream from duct silencers.

H. 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 should 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)

I. Install flexible duct 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 duct runs shall not exceed 5 feet in length. Utilize the minimum length of duct to make the connections.
2. Flexible ductwork shall be installed straight as possible avoiding tight turns with a maximum of one 90 degree bend in any length. Install flexible duct fully extended minimizing compression.
3. Provide continuous length with no intermediate joints.
4. Support flexible duct 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. Ductwork shall not be crimped against joist or truss members, pipes, conduits, etc.
8. The bend radius at the center line shall be equal to or greater than one duct diameter.
    a. Support bends approximately one duct diameter on both sides of bends.
9. Connections to ductwork and air devices shall have at least 1" overlap.

J. Provide rigid duct elbow or flexible elbow assembly 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.

3.03 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.

3.04 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 23 33 00

SECTION 23 34 23
HVAC POWER VENTILATORS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Inline centrifugal fans.

1.02 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.

1.03 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.

1.04 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. Kitchen Hood Exhaust Fans: Kitchen hood exhaust fans and components shall comply with requirements of UL 762 and NFPA 96.

D. 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.

E. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

F. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.06 FIELD CONDITIONS

A. Permanent fans may not be used for ventilation during construction.

PART 2 - PRODUCTS AND MATERIALS

2.01 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. Motors: Refer to Section “Common Motor Requirements for HVAC Equipment” for requirements.

G. 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.

H. Hazardous Duty: Provide fans with spark resistant construction and explosion proof motor where specified in the schedule.

I. 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.

2.02 UPBLAST ROOF EXHAUSTERS

A. Manufacturers:
   1. Accurex.
   2. Acme Engrg. & Mfg. Corp.
   3. Carnes Company, Inc.
   4. Cook (Loren) Co.
   5. Greenheck Fan Corp.
   6. Hartzell Fan, Inc.
   7. PennBarry.
   8. RuppAir Management Systems
   9. 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 motoractuator.

e. Operators: Manufacturer's standard pneumatic motoractuator.

PART 3 - EXECUTION

3.01 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of structural steel support members.

3.02 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.

3.03 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.

3.04 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.

3.05 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 23 34 23

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of air terminals specified in this section include the following:

1. Variable Air Volume Terminal Units

a. Shutoff Single Duct

b. Reheat

1.02 QUALITY ASSURANCE

A. Codes and Standards:

1. ADC Compliance: Provide air terminals which have been tested and rated in accordance with ADC standards, and bear ADC Seal.

2. AHRI Compliance: Provide air terminals which have been tested and rated in accordance with AHRI 880 "Industry Standard for Air Terminals" and bear AHRI certification seal.

3. NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".

4. UL/ETL Compliance: Air terminal units shall be UL or ETL listed as a complete assembly. All electrical components shall be UL listed and installed in accordance with the National Electric Code.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; certified sound power data for each unit; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions.

B. Nameplate Data: Nameplate data shall be submitted in a timely manner so as to allow proper coordination with the Electrical Contractor. Submittals that do not have nameplate data will be rejected.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

D. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

E. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of Division 1.

1.04 SPARE PARTS

A. If HVAC equipment is used during construction, the contractor is fully responsible for it’s cleaning just before substantial completion prior to testing and balancing.

PART 2 - PRODUCTS AND MATERIALS

2.01 VARIABLE AIR VOLUME TERMINAL UNITS

A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide air terminals of one of the following:

1. Johnson Controls, Inc (VRU).
    a. Contact: Kevin Tolbert
    b. email: kevin.p.tolbert@jci.com
    c. 478-952-8740
2. Siemens Industry Inc.
    a. Contact: Edward Tambornino
    b. email: ed.tambornino@siemens.com
    c. 847-271-8136

C. Casings: Construct of galvanized sheet metal of minimum 22 gauge thickness or die-cast aluminum of minimum 20 gauge thickness.

1. Provide hanger brackets for attachment of supports.
2. Linings: Line inside surfaces of casings with lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of 1/2". Lining shall be closed cell foam and comply with UL 181 and NFPA 90A. Insulation shall be 1-1/2 lb. density.
3. Access: Provide removable panels in casings to permit access to air dampers, fans and other parts requiring service, adjusting, or maintenance.
    a. Provide airtight gasket and quarter-turn latches.
4. Leakage: Construct casings such that when subjected to 0.5-in w.g. pressure for low pressure units, and 3.0-in w.g. pressure for high pressure units, total leakage does not exceed 2% of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0-in w.g. inlet pressure with damper closed, total leakage does not exceed 5% of specified air flow capacity.

D. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume thru damper for minimum to maximum, in response from signal from thermostat.

E. Controls: Provide controls accurate to 1.5 degrees F and adjustable from 65 degrees F to 85 degrees F. Provide air flow measurement station at terminal unit inlet. Provide control type as indicated below.

1. Provide direct digital controls, compatible with direct digital control system specified in other Division 23 sections.

F. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory-setting, and calibration curve (if required).

G. Heating Coils: Provide the following features as indicated on Drawings and schedule:

1. Hot Water Heating Coils: Provide heating coils constructed of copper tubes and aluminum fins with galvanized steel casing.
2. Hot water coils shall be factory installed with a maximum of ten (10) aluminum fins per inch and rated in accordance with ARI 410.The coil circuiting shall be a multi circuited header with corrosion free brass manual air vent piped in at the highest and lowest point of the piping header to ensure efficient drainage and air removal from the coil. A metal coil-u-bend cover shall to be factory installed on the coil u-bends to protect the coil u-bends during shipment and installation. Upstream and downstream coil casing connections to terminal unit and duct extension to be sealed with silver foil tape rated at 6" TSP. Tube thickness shall be a minimum of 0.016″
3. Braided stainless steel hose kits are acceptable for terminal boxes. Hoses to be a minimum of ¾" diameter and 24" long and to have operating temperature range from -40° to 250° Fahrenheit, a working pressure of 400 psi, and a minimum burst pressure of 1600 psi. . Hose kits to ship with one end attached to the VRU piping valve assembly and the other end with a minimum 3/4" diameter 8 " long sealed copper air chamber. The sealed end of the copper air chamber should be cut, prepped and connected to the loop piping. Do not twist the hose kit during installation and keep all flux and other chemicals off the braided hoses. Pay close attention during construction to allowable hose bend radius.
4. VAV boxes serving operating rooms and C-section rooms shall have a minimum of two-rows for rapid room warm-up. Heating coils in all other VAV terminal units shall be selected to maintain a minimum space temperature of 75˚F with 140˚F hot water supply temperature. Two-row coils are preferred in all applications to reduce fan power requirements and sound transmission.
5. Two (2) 90 degree copper pipes formed on a tube bender shall be sweated directly to the header of the coil with a minimum distance of 6 inches from the coil inlet and to the coil outlet regardless of the coil size. Sweated copper elbows and fittings are not acceptable to achieve the same result.
6. Terminal box assembly shall consist of factory fabricated terminal unit, integral controls, coil, piping of the sizes, capacities and configurations shown on the drawings with catalogued part numbers. All controls and hydronics piping shall be accessible from the same side of the unit. All hydronics piping packages shall be piped in the opposite direction of the control panel, downstream of the VAV terminal unit. Controls Contractor shall be responsible for proper selection/sizing of the VAV based on scheduled performance parameters and the supplying of the VAV.
7. The piping assembly and coil shall be field reversible. The hydronics piping structure and 2 handle shipping brackets shall be attached to the coil inlet and outlet connections as one assembly integral to the VAV. All piping assemblies for the VAVs supplied shall be identical and interchangeable for inlet sizes of four (4) inch through 24 inch. The supply and return aspect ratios of the inlet and outlet piping shall be 6 inch on center of the coils. The piping aspect ratio is identical for all VAVs supplied regardless of VAV box/coil size.
8. The following minimum factory installed piping components shall be supplied; a valve package consisting of a stainless steel ball valve with a #20 stainless steel screen to act as a strainer, a union, P/T (pressure temperature) port, drain or blow-down with integrated stainless ball valve and removable brass end cap to seal the drain connection. Union with P/T port. All P/T ports require an extension of a minimum of 1.5 inches. Stainless steel isolation valve, union, and P/T readout ports. Pressure gauge to confirm 100% leak free product delivery. Type "L" ¾ inch copper pipe. Two (2) 24 inch long stainless steel hose kits tested to meet UL94 with a VO rating and a washer-less design with a 6" long 3/4:" sealed copper air chamber attached to each end of the hose.

9. Memory stops shall not be provided with VAV boxes, but shall be available from the manufacturer for field retrofit without the need to replace the entire valve, should the need arise.

10. A ½ inch control valve with stainless steel ball and stem shall be provided and factory installed in the piping trim at the factory. A 24 volt electric non-spring return modulating valve actuator shall be provided. The actuator wires shall be terminated to the VMA controller. Both the actuator and control valve shall be tested before leaving the factory.

11. The entire VAV assembly (terminal unit, coil, hydronics piping packages, controls hardware, electrical components and wiring) shall be seismically certified per IBC 2010 code with a 2.5 allowance factor and carry the OSHPD (OSP) certification.

12. If required for single-side access, single duct terminal units with hot water coils shall be shipped with a factory supplied 16 inch duct extension attached downstream of the coil. The construction of the duct extension shall be equal to the quality of materials and workmanship to that of the terminal unit. All connections to be sealed with silver foil tape rated at 6" of total pressure. The insulation shall match the insulation of the VAV box.

H. A control panel manufactured with a minimum 20 gauge sheet metal shall be supplied. The enclosure cover design shall allow for the following motions with a single universal design: a 180 degree hinged motion, a sliding motion from left to right and right to left including full removal of the enclosure cover without tools. The controls cover shall reside in a set position without the use of mechanical fasteners or screws. "Quick Release" sheet metal tabs/guide stops shall be supplied to allow the cover from slipping off when in the fully open position. The "Quick Release" tabs/guide stops shall be designed in such a way to allow the complete removal of the cover. A handle shall be supplied on the controls cover for opening and closing the controls cover. The control enclosure shall have factory installed knock outs for mounting all the electrical and controls components required. All electrical and electronic components including both line voltage and low voltage shall be mounted in the metal controls enclosure per applicable codes. The control panel shall include stand-offs to allow mounting of the controls and electrical items without penetrating the VAV terminal box casing.

I. A transformer with primary and secondary transformer fusing with a toggle disconnect switch shall be provided and installed at the factory. All secondary wiring from the toggle switch and transformer to the VMA vav controller shall be factory installed and tested before shipment.

J. A platinum 1k ohm DAT (Discharge Air Temperature) Sensor shall be provided. The DAT sensor shall have a stainless steel mounting flange with two hex-head self-drilling mounting screws and come equipped with a 10 ft plenum rated cable with ¼" female insulated quick-connect terminator leads. Cable must meet UL 1995 requirements for installation within an air plenum. The DAT sensor shall be factory installed in the duct extension at the farthest point downstream of the coil. The DAT sensor shall be factory checked for proper resistance range and factory-wired to the VMA- 1630 controller.

K. A VAV box controller shall be provided and factory installed. All wiring from the DAT, transformer and control valve shall be connected and tested at the factory. The pneumatic tubes from the air flow sensor shall be connected to the controller transducer at the factory

L. A minimum of two adjustable Universal Handle Brackets with built in handles shall be supplied for every VAV furnished. Handles shall be constructed with a minimum of 14 gauge metal shall be painted to avoid corrosion and stress fractures of hydronics. Handle opening shall be able to accept a minimum of the following lifting devices through the handle portion of the bracket without damaging the product: human hand, forklift, Unistrut, pipe or other lifting devices. The handle shall have a 180 degree – "rolled up edge" to prevent injury to the human hand: raw edges or non-rolled edges shall not be accepted.

M. The shipping handle brackets shall use 4 military grade rubber grommets for elimination of galvanic corrosion and isolation between copper piping and support handles. The rubber grommets shall be made of Buna-N and be resistant to petroleum-based oils and fuels, water and alcohols.

N. Four aircraft cables shall be factory installed on the VAV with the job specific platform fastening mechanism at the end of the aircraft cables. Cables shall be a minimum of 10 feet long. Cables shall be rated for a minimum of 100 lbs each with a 5:1 safe working load allowance.

O. All sound data shall be compiled in an independent ADC certified laboratory and in accordance with the latest version of AHRI 880. All units shall be AHRI certified and bear the AHRI certification label.

PART 3 - QUALITY ASSURANCE

A. The hydronics piping structure and coil shall be charged with nitrogen or other appropriate dry gas at the factory before shipment at greater than sea level pressure at the assembly area; seal the gas in the piping structure: Test the sealed piping structure and coil for a minimum of 12 hours to determine whether the gas stays within the hydronics Piping Structure and coil through the use of a pressure gauge. If the gas leaks from the hydronics piping structure per the pressure gauge identify the leak, fix it and re-test upon verification of the piping structure having zero leakage of the gas prior to shipment.

B. Transport the sealed and pressurized piping structure with coil from the factory to the construction site; determining a pressure of the gas at the construction site. If hydronics structure and coil arrives without holding pressure, then Contractor to trouble shoot and fix leak.

C. Inside of terminal unit and duct extension to be cleaned and wiped down. Inlet and discharge shall be wrapped with a protective cover. All VAVs shall be individually tagged, strapped down, palletized, enclosed in cardboard boxes and shrink wrapped with a pallet stretch machine. Labels with bar codes shall be adhered to the to each unit with the following information: Tag numbers, Model no, Serial no., Date of manufacture, Manufacturer, Inlet size, MFG, ID # and Job Name. Electrical wiring schematic shall be adhered to the outside of each control enclosure. Additional tagging to be placed on the outside of the cardboard box shrink wrapping. Shipping boxes shall list all relative shipping information including reference ID no., telephone number and name of person/entity receiving the product(s), and tags of individual VAV units on the pallets

D. Inlet of terminal unit and outlet of duct extension to be sealed with a plastic wrap to keep air borne particles out of the inlet and outlet of the VAV. In addition, the entire assembly shall be wrapped and secured to the shipping pallet.

E. Factory Commissioning of Controls and Software

1. Load appropriate VAV program into the DDC controller and program all the performance parameters commensurate for each zone/VAV unit per schedule supplied by the controls contractor

2. Properly address each controller with the correct address in order for the BAS system to identify each DDC controller.

3. Power up the VAV and run the program through full cycle operation. Stroke the damper actuator to full open and then to closed position. Stroke the temperature control valve to full open and full closed.

4. Set and Ship all actuators in the open position

F. Digital Data Retrieval System – VAV manufacturer shall provide the following as part of the Operational and maintenance manuals in digital form:

1. Digital images of each individual VAV shipped including the hydronic piping packages, controls hardware, electrical, coil and terminal unit taken before shipment.
2. Controller software and individual VAV performance files specific for each VAV by tag number.
3. Approved Submittals
4. Operational and maintenance instructions
5. Drawings
6. Part numbers

PART 4 - EXECUTION

4.01 INSTALLATION

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

B. The HCA standard is that heating coils on VAV boxes are not provided with individual balancing valves. Balancing valves are instead to be provided at every floor, wing, and at every branch serving a minimum of 3 VAV boxes. Confirm balancing of individual terminal box is not included in the base scope of work of the Test and Balancing agent.

C. Provide shutoff valves as required for maintenance and replacement without a large-scale shutdown of equipment.

D. The mechanical contractor is to provide and install a set of isolation valves at the connection of the hot water distribution piping and the braided steel hoses so the boxes can be isolated from the rest of the system in the event of a hose failure.

4.02 FIELD QUALITY CONTROL

A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.

B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

4.03 ADJUSTING AND CLEANING

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.

END OF SECTION 23 36 00

SECTION 23 37 13
DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this Section.

B. Types of outlets and inlets required for project include the following:

1. Ceiling air diffusers.
2. Wall registers and grilles.

C. Refer to other Division 23 sections for ductwork and duct accessories required in conjunction with air outlets and inlets; not work of this Section.

D. Refer to other Division 23 sections for balancing of air outlets and inlets; not work of this Section.

1.02 RELATED REQUIREMENTS

A. 230548 – Seismic Controls for Mechanical Systems, for seismic controls.

1.03 QUALITY ASSURANCE

A. Codes and Standards:

1. AHRI Compliance: Test and rate air outlets and inlets in accordance with AHRI 650 "Standard for Air Outlets and Inlets".
2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".
3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".
4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.
5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters".
6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.
7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.04 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.
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. Indicate selections on data.
4. 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.
5. 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.

B. 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.

C. 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.

D. Samples for Verification: Provide samples of diffusers, registers, and grilles, in manufacturer's standard sizes, showing the full range of colors. Prepare Samples from the same material to be used for the Work.

1.05 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 AND MATERIALS

2.01 CEILING AIR DIFFUSERS

A. 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.

B. 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.

C. 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.

D. Linear Slot Diffusers: Slot diffusers shall be standard one-piece lengths up to 6-feet and shall be furnished in multiple sections greater than 6-feet. Multiple sections shall be joined together end-to-end with alignment pins to form a continuous slot appearance. All alignment components shall be provided by the manufacturer. Plenums shall be manufactured by the slot diffuser manufacturer. Plenums shall be internally insulated, by the manufacturer, with minimum ¼" thick, closed-cell insulation. Insulation shall not be made of fibrous material.

E. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as scheduled on the drawings.

F. Manufacturers: Subject to compliance with requirements, provide diffusers of one of the following:

1. Carnes Co.
2. Price Industries, Inc.
3. Krueger Mfg. Co.
4. Metalaire; Metal Industries, Inc.
5. Nailor Industries, Inc.
6. Titus HVAC
7. Tuttle & Bailey; Div. of Air Systems Components, Inc.

2.02 REGISTERS AND GRILLES

A. 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.

B. Performance: Provide wall 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.

C. 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.

D. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as scheduled on the drawings.

E. Manufacturers: Subject to compliance with requirements, provide registers and grilles of one of the following:

1. Carnes Co.
2. Price Industries, Inc.
3. Krueger Mfg. Co.
4. Metalaire; Metal Industries, Inc.
5. Nailor Industries, Inc.
6. Titus HVAC
7. Tuttle & Bailey; Div. of Air Systems Components, Inc.

PART 3 - EXECUTION

3.01 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.

3.02 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 insure 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 “Metal Ducts”.

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.

3.03 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before beginning air balance.

3.04 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 23 37 13

SECTION 23 73 13
OUTDOOR CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes constant and variable volume, central-station air-handling units with coils for indoor installations.

1.02 SUBMITTALS

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

1. Product data for each central-station air-handling unit indicated, including the following:
    a. Certified fan performance curves with system operating conditions indicated.
    b. TMA asset tracking
    c. Report unweighted octave band AHU sound power for inlets and outlets rated in accordance with AHRI Standard 260. Provide eight data points, the first for the octave centered at 63 Hz, and the eighth centered at 8,000 Hz. Manufacturer shall not use sound estimates based on bare fan data (AMCA ratings), nor use calculations like the substitution method based on AHRI 260 tests of other AHU products. Provide data for inlets and outlets as scheduled. Report unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.
    d. Certified coil performance ratings with system operating conditions indicated.
    e. Motor ratings and electrical characteristics plus motor and fan accessories.
    f. Provide short circuit current rating of units with factory mounted starter or variable frequency drive.
    g. Materials, gages and finishes.
    h. Filters with performance characteristics.
    i. Dampers, including housings, linkages, and operators.
    j. Airflow measuring device performance shall be certified and rated in accordance with AMCA-611. Report data in accordance with AMCA-611. Provide AMCA Certified Rating Seal for Airflow Measurement Performance.
    k. Report panel deflection at +/-8” w.g., stated in terms of ‘L/X’ where ‘L’ is the casing panel length and ‘X’ is a constant provided by the AHU manufacturer.
    l. Report casing leakage rate at +/-8” w.g., specified in terms of percentage of design airflow.
    m. Report weight loads and distributions by component section.
    n. Report product data for filter media, filter performance data, filter assembly, and filter frames.
2. Shop drawings from manufacturer detailing dimensions, weights, required clearances, components, and location and size of each field connection.
3. Adjust and report performance ratings for the proper altitude of operation.
4. Wiring diagrams detailing wiring for power and controls and differentiating between manufacturer-installed wiring and field-installed wiring.
5. Product certificates signed by manufacturers of central-station air-handling units certifying that their products comply with specified requirements.
6. Maintenance data and recommended spare parts list for central-station air-handling units for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 23 Section "General Mechanical Requirements."

1.03 QUALITY ASSURANCE

A. NFPA Compliance: Central-station air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA Standard 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. UL Compliance: Electric coils, along with the complete central-station air-handling unit, shall be listed and labeled by Underwriters' Laboratories.

C. Nationally Recognized Tested Laboratory and NEMA Compliance (NRTL): Electric coils, along with the complete central-station air-handling unit shall be listed and labeled by a NRTL. The term “NRTL” shall be as defined in OSHA Regulation 1910.7.

D. AHRI Certification: Central-station air-handling units and their components shall be factory tested in accordance with the applicable portions of AHRI 430 - Standard for Central-Station Air-Handling Units and shall be listed and bear the label of the Air-Conditioning and Refrigeration Institute.

E. Air Handling Unit safety: ETL or UL 1995

F. Air Handling Unit energy use: ASHRAE 90.1

G. Fans: AMCA 210

H. Air Coils: AHRI 410

I. Air Handling Unit certification program: ANSI/AHRI 430

J. Filter media: ANSI/UL 900 listed Class I or Class II

K. Control wiring: NEC codes & ETL requirements

L. Motors: Federally mandated Energy Policy Act (EPACT).

M. Airflow Monitoring Stations: AMCA 611-95

N. Units shall be seismically certified in accordance with applicable IBC 2000, 2003, 2006, 2009 or 2012 and applicable Building Code for life safety environments.

O. Manufacturer shall have a minimum of 25 years of experience in designing, manufacturing, and servicing air-handling units.

P. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer.

1.04 COORDINATION

A. If equipment is supplied other than as shown on plans, coordinate with the General Contractor and affected subcontractors. This coordination shall include (but is not limited to) the following:

1. Structural supports for units.
2. Size and location of concrete bases/housekeeping pads
3. Location of roof curbs, unit supports and roof penetrations
4. Ductwork sizes and connection locations
5. Piping size and connection/header locations
6. Interference with existing or planned ductwork, piping and wiring
7. Electrical power requirements and wire/conduit and over current protection sizes.
8. Trap height requirements

B. The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished other than as shown as basis of design.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).

B. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from moisture by appropriate in-transit and on-site procedures.

C. Follow manufacturer's recommendations for handling, unloading and storage.

D. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

E. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

F. Enclose and protect control panels, electronic or pneumatic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

G. Seal openings to protect against damage during shipping, handling and storage.

H. Wrap indoor and outdoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively AHU must be tarped for shipment and storage.

I. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

J. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

1.06 SPARE PARTS

A. General: Furnish to Owner, with receipt, the following spare parts for each air-handling unit.

1. 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.
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.
3. In addition to the set of filters provided with the air handler, provide one clean set for balancing, and one additional set for final turnover to owner, for a total of 3 sets of filters provided.
4. Furnish one additional complete set of belts for each central-station air-handling unit.
5. Furnish one additional gasket for each sectional joint of each central-station air-handling unit.

1.07 WARRANTY

A. Provide entire unit parts and labor warranty for 12 months from date of substantial completion. Warranty shall cover manufacturer defects. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician.

B. For air handlers provided with UV lights, include service contract to replace bulbs once per year for five years after startup. Contract must include materials and labor to install new and dispose of old bulbs.

C. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on schedule as YORK, div. of Johnson Controls Inc.

2.02 MANUFACTURED UNITS

A. The owner requirement is for modular type air handlers where possible. Custom type equipment is only to be applied where absolutely necessary.

B. Air Handling Unit (AHU) consists of a structural base, insulated casing, access doors, fans, motors, motor controls, coils, filters, dampers, components, and accessories; as shown on drawings, schedules, and specifications.

C. Provide AHU to meet the specified levels of performance for scheduled items including airflow, static pressure, cooling capacity, heating capacity, electrical characteristics, sound, casing leakage, panel deflection and casing thermal performance.

D. Provide internal components and accessories as specified and scheduled. Components and accessories shall be installed by the AHU manufacturer.

E. Ship units in one piece. Split units only where necessary for shipping and installation.

F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.

G. For AHU segments that must be broken down for rigging and installation: segment shall be disassembled and reassembled by manufacturer's factory-trained service personnel.

2.03 STANDARDS COMPLIANCE

A. Comply with ratings and certifications referenced in this specification.

B. Manufacturers who do not comply with ANSI/AHRI-430 shall factory test EACH unit to verify brake horsepower rating, airflow performance and total static pressure performance.

C. Manufacturers who do not conform to requirements of AHRI 260 for ducted discharge and return air sound shall submit EACH unit to an independent sound test laboratory for AHRI 260 testing. The test laboratory shall conform to AHRI 260, Section 4.4, Test Equipment and Facilities.

2.04 BASE RAIL

A. Provide a structural base rail under the full perimeter of the unit

B. Provide clearance for proper external trapping of drain pans without the need to cut the floor.

C. Provide base rail and lifting lug system that does not require additional support for rigging. Include base rail lifting lugs at unit corners.

2.05 CABINET

A. Provide 2" double wall AHU casing. Exposed insulation is not acceptable.

B. Panel assembly shall meet UL standard 1995 for fire safety. Panel insulation shall comply with the requirements of NFPA 90A.

C. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.

D. Encapsulate insulation with sheet metal so that air does not contact insulation. Solid lined panels insulated with spray injected foam shall be hermetically sealed at each corner and around their entire perimeter, to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall. Foam insulation shall fully fill entire floor, all walls, and roof with no voids.

E. Provide casing with minimum thermal resistance (R-value) of 13 hr-ft2-°F/BTU for indoor applications and 16 hr-ft2-°F/BTU for outdoor. The casing shall incorporate thermal breaks as required so that when assembled, minimal path(s) of continuous unbroken metal to metal conduction from inner to outer surfaces exist.

F. All exterior (minimum 18 gauge) and interior (minimum 20 gauge) casing panels (roof, wall, access door) shall be made of G90 galvanized steel. Interior casing panels (walls and floor) shall be made of 304 stainless steel within wet sections – from cooling coil or humidifier up to supply fan bulkhead. Units installed within 60 miles of the coast shall also include 304 stainless steel walls in outdoor air sections up to the cooling coil.

G. Floors shall be provided with 0.125" aluminum diamond tread plate liner for units 48" and greater in height. Units below 48" in height shall have 14 gauge G90 galvanized steel floors in dry

sections and 14 gauge 304 stainless steel floors from cooling coil or humidifier to fan bulkhead. Units shorter than 48" installed within 60 miles of the coast shall also have 14 gauge 304 stainless steel floors in outdoor air sections up to the cooling coil.

H. Provide a unit frame of galvanized steel that provides the overall structure of the unit and does not rely on the casing panels for structural integrity.

I. Unit shall conform to ASHRAE Standard 111 Class 6 for casing leakage no more than 1.0% of design airflow at 1.25 times design static pressure up to a maximum of +8 inches w.g. in positive pressure sections and -8 inches w.g. in negative pressure sections. The unit leakage is the sum of the leakage in all positively and negatively pressurized sections of the air handler.

J. Provide wall panels and access doors that deflect no more than L/240 when subjected to 1.5 times design static pressure up to a maximum of +8 inches w.g. in positive pressure sections and -8 inches w.g. in negative pressure sections. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

K. Provide floors and roofs that deflect no more than L/240 when subjected to a 300 lb static load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

L. Provide outdoor AHUs with a roof system that deflects no more than L/240 when subjected to a static snow load of 30 lb/ft2. 'L' is defined as the panel-span length and 'L/240' is the deflection at the panel midpoint.

M. Provide outdoor AHUs with a roof sloped at a minimum pitch of 1/4" per foot. The roof shall overhang side and end panels by a minimum of 2."

N. Provide an exterior finish for outdoor AHUs that show a breakdown of less than 1/8" on either side of a scribed line when subjected to ASTM B117 500 hour, 5% salt spray conditions. This is equivalent to an ASTM D1654 rating of '6.'

2.06 PRIMARY DRAIN PANS

A. Panel assembly shall meet UL standard 1995 for fire safety. Panel insulation shall comply with the requirements of NFPA 90A.

B. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.

C. Provide floors that deflect no more than L/240 when subjected to a 300 lb load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint

D. Comply with the stated intent of ASHRAE Standard 62.

E. Provide a drain pan under each cooling coil and humidifier. Drain pans for cooling coils and humidifiers shall meet the requirements of ASHRAE 62.

F. Drain pans shall be stainless steel.

G. Provide drain connection made of same material as drain pan. Do not use dissimilar metals because of the risk of galvanic corrosion. Weld connection to the drain pan.

H. Cooling coil drain pan shall be double wall construction with an insulation R-value of 13 hr-ft2-°F/ (BTU-in). Low temp glycol coils shall be provided with additional 2" insulated drain pan subfloor. Drain pans shall be extended as much as possible without making the section longer.

I. Provide drain pan under the complete width and length of cooling coil and humidifier sections. Drain pan shall be full width, and completely extend to next section downstream of cooling coil and humidifier within AHU without growing section length. Pan shall extend a minimum of 12" downstream of cooling coil except where the length is limited due to the installation of UV lighting.

J. Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.

K. Provide a minimum of 1" clearance between the drain pan and any coil casing, coil support or any other obstruction.

L. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.

M. Provide drain pan sloped in at least two planes by at least 1/8" per foot toward a single drain. Locate drain connection at the lowest point of the pan. Pan shall have no horizontal surfaces.

2.07 ACCESS DOORS

A. Provide thermal break, double wall access door(s) that meet requirements for the AHU casing.

B. Provide industrial-style stainless steel hinges that permit 180 degrees of door swing.

C. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or "paw" latches are not acceptable.

D. Provide each door with a single handle linked to multiple latching points or a separate handle for each latching point. Doors serving access segments shall have an interior latch handle.

E. Provide access doors with a locking hasp to accommodate a lockout device.

F. Where permitted by code, provide double-pane viewing windows in all fan access sections, humidifier sections and upstream of all filter sections. Windows shall be a non-condensing type consisting of a desiccant dehumidification layer. Minimum dimension shall be 8" x 8".

G. Provide VentLok 699 Test Port and gasket in all door systems and as needed to provide at least one port upstream and one port downstream of every coil and filter.

H. Access doors, where permitted by code, are always to open against positive pressure.

2.08 ROOF CURBS

A. Provide insulated factory-fabricated galvanized steel roof curb for outdoor units in accordance with local codes and seismic compliance. Roof curb shall support the full-perimeter of the air handling equipment, including pipe chases.

B. Match roof curb to roof slope. Curb surface shall be level in both axes.

C. Provide wood nailing strip to which roofer may nail roof flashing.

D. Ship roof curb loose for field installation prior to unit placement.

2.09 FANS SECTION

A. Direct drive fans are preferred over belt drive. As much as is practical, provide a minimum of two fans for all air handlers serving critical care or otherwise patient-facing areas. Evaluate the life cycle cost before specifying fan arrays with more than two fans.

B. Provide, at a minimum, two single width, single inlet (SWSI) plenum fans with 1800 or 1200 RPM motors for units above 12,000 CFM. For units below 12,000 CFM, 3600 RPM fan arrays may be used unless two 2400 RPM fans can meet the capacity.

C. Eighty hertz is the maximum allowed at design conditions unless approved by FacilitiGroup Engineer.

D. Unless prohibited by code, fans shall not be selected for operation within 85% of MAX Fan RPM and BHP is not to be within 85% of motor nameplate HP. Fan selections shall incorporate a total final filter pressure drop of 1.5" w.c. and a total pre-filter pressure drop of .85" w.c. along with all inlet and discharge opening static pressure drops at design CFM.

E. Maximum motor HP shall be 30 HP.

F. Airfoil fans shall comply with AMCA standard 99 2408 69 and 99 2401 82. Provide an AMCA seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.

G. Provide fans with true airfoil blades unless otherwise scheduled.

H. Provide fans with the following accessories:

1. Fan inlet screens
2. OSHA-compliant belt guard enclosing the fan motor and drive (if belt driven)

I. Provide airfoil fans with blades formed of extruded aluminum, as scheduled. Bent sheet metal blades are not acceptable.

J. Provide fans with polished steel shafts with first critical shaft speed at least 125% of the maximum operating speed for the fan pressure class. Shaft shall have an anti-corrosion coating.

K. Mount the fan and motor assembly on a common adjustable base. This common base shall attach to vibration isolators, which mount to structural support channels. These channels shall span the AHU floor and mount directly to the AHU frame.

L. Provide adequate vibration isolation with seismic snubbers.

M. Provide horizontal thrust restraints between AHU casing and fan housings.

N. Multiple Fans (Array of Direct-Drive Plenum Fans) shall be Model MPQ centrifugal plenum type, as manufactured by Twin City Fan & Blower, or Model HPA, manufactured by Greenheck.

1. Performance — Fans shall conform to AMCA test standards, 205 (fan efficiency grade), 210 (air performance) and 300 (sound performance) and shall bear the AMCA certified ratings seal for both sound and air, and fan efficiency grade (FEG). Sound certification shall apply to both inlet and outlet sound power levels.
2. Construction — Fans shall be housed and incorporate a non-overloading type backward inclined airfoil blade wheel, heavy-gauge galvanized G90 steel frame, and front panel. The front panel shall have a removable inlet cone designed for smooth airflow transition into the wheel. The motor base shall be designed to ensure proper alignment of the fan wheel, motor and inlet cone. The design shall also ensure the structural integrity of the base to minimize vibration.
3. Wheel — Wheels shall be constructed of non-overloading extruded airfoil shaped blades. Airfoil blades shall be continuously welded. The entire wheel shall be constructed of aluminum to reduce weight and vibration. Blades shall be extruded aluminum. Wheel hubs shall be machined aluminum. Aluminum fan wheels shall not require a finish coating. Wheels shall be attached to the motor shaft using taper lock bushings. The wheel and fan inlet shall be matched and have precise running tolerances for maximum performance and operating efficiency.
4. Finish and Coating — Fans shall be constructed of corrosion resistant galvanized steel. Aluminum components shall be unpainted.
5. Motors — Motors shall meet or exceed EISA 2007 (The Energy Independence and Security ACT of 2007) efficiencies. Motors shall be NEMA rated, 720, 900 1200, 1800 or 3600 RPM in 60 Hz, Open Drip Proof (ODP) or Totally Enclosed Fan Cooled (TEFC) with a 1.15 service factor.
6. Fan Balancing — All fans prior to shipment shall be run tested at the specified operating speed. Each fan shall be dynamically balanced as a complete unit in accordance with ANSI/AMCA 204-96 “Balance Quality and Vibration Levels for Fans” to a minimum Fan Application Category BV-3, Balance Quality Grade G6.3. Balance readings shall be taken electronically in the axial, vertical and horizontal directions. Records of each fan balance shall be maintained and a written copy shall be available upon request.
7. Blank off Panels — Each Multiple Fan section to be provided with fan blank-off panels to enable manual isolation of fan for servicing. Quantity of panels shall equal number of fans on a single VFD. Backdraft dampers (barometric or controlled) shall not be permitted.
8. Fan Options — The following options shall be available for multiple fans:
    a. Piezometer Ring: Rings shall be factory installed in each fan inlet. The device shall have a measurement accuracy of ± 5%. Tubing shall be field installed along with corresponding air flow monitoring station by DDC controls contractor so that the measurement is representative of all fans in the array.

O. Fan Array Motor Control (common VFD operation with Array split into two banks)

1. All fan motors shall be factory-wired to individual manual motor protection (MMP) device which shall consist of a motor overload relay with adjustable current rating and an on-off disconnect switch (one per motor) for power isolation. Field wiring of MMPs to fan motors shall not be permitted.

2. MMPs shall be contained in a single control panel (MMP panel) and shall be mounted on the exterior wall panel of the fan array section.
3. MMP panel shall have a single point of connection for input power wiring and shall feed power individual MMP's through a common bus bar. Independent wiring of input power to individual MMP's shall not be permitted.
4. All VFDs shall be operated together from a single control point so that all fan motors operate together. Independent control of VFDs and fan motors shall not be permitted.

2.10 BEARINGS AND DRIVES

A. Provide bearings complying with ANSI/AFBMA 9 for fatigue life ratings.
B. Provide fan bearings with an average life L10 of at least 200,000 hours, as scheduled.
C. Provide re-greaseable bearings with hydraulic grease fittings and lube lines extended to the motor side of the fan.
D. Provide direct-drive plenum fans.

2.11 MOTORS

A. Provide fan motors built in accordance with the latest standards of the NEMA and IEEE.
B. Provide AHU and fan motors in compliance with ASHRAE 90.1.
C. Provide fan motors with the following characteristics:
   1. Voltage, Frequency and Phase, as scheduled.
   2. Motor RPM, as scheduled
   3. Minimum service factor of 1.15
   4. Premium efficiency, or as required to meet ASHRAE 90.1
   5. NEMA design ball bearing type
   6. Rated for continuous duty at full load in a 104□F (40□C) ambient
   7. Open drip proof (ODP) or totally enclosed, fan cooled (TEFC) as scheduled.
   8. Suitable for use in variable frequency application, per NEMA MG-1 Part 30
   9. Shaft Grounding Rings
   10. Premium Efficiency Inverter ready per NEMA STD MG1 PART 31.4.4.2
D. Where practical, provide electronically commutated motors for fractional horsepower applications.

2.12 FAN-MOTOR VARIABLE FREQUENCY DRIVES (VFDS)

A. Variable Frequency Drives shall be provided as follows:
   1. Dual Fans: One (1) VFD per fan motor with fused main disconnects.
   2. Fan Arrays: One (1) VFD with motor protection panel per half of fan array with fused main disconnects.
B. Provide UL or ETL listed VFDs and associated components, as scheduled and shown on drawings. VFDs shall comply with applicable provisions of the National Electric Code.
C. Mount VFDs in a dedicated NEMA 1 compartment located on the primary access side of its associated fan section and wire VFD to motor, unless otherwise indicated on drawings.
D. Enclose outdoor VFDs in a NEMA 3R enclosure suitable for use in ambient temperatures from -20□F to 135□F:
E. After unit installation, VFD shall be started and programmed by a factory trained and employed service technician. Refer to Section Part 3 - Execution3.5.
F. Refer to 26 29 23 for complete requirements for VFDs.
G. Drives are to be provided without bypass, except in the case of a single-fan application.

2.13 FACTORY INSTALLED ELECTRICAL ACCESSORIES

A. In addition to motor power terminals, provide an independent power terminal for convenience receptacles and lights. Provide switches as shown on drawings.

B. Provide LED (light emitting diode) lights in segments as scheduled or shown on drawings. Provide light switches as scheduled or shown on drawings. Lights shall be constructed of safety glass and suitable for wet locations.

C. Provide a 1-hour timer on external light switches.

D. Provide a 20A 120V convenience receptacle on supply fan segment. Receptacle shall be powered separately from fan VFD so it remains energized when fan disconnect is open.

E. Disconnects and VFDs are to be installed as close as practical to the fan motor they serve. Where factory-mounted disconnects are to be provided on stacked units, they are to be installed such that they can be reached by a service technician standing beside the unit without the use of a ladder.

F. Where maintenance platforms are anticipated for ease of access to the upper level, disconnects are to be installed adjacent to, and on the same level as, the access door to the motor it serves.

2.14 COILS

A. Provide coils manufactured by AHU manufacturer, except where noted in contract documents.

B. Coils shall meet or exceed performance scheduled on drawings.

1. When applicable, provide coils with performance certified in accordance with AHRI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at design flow.

C. Provide cooling coils with a maximum face velocity of 450 FPM. Face velocity calculations shall be based on the finned area of the coil. Manufacturer shall guarantee zero carryover at 500 fpm.

D. Coils shall be provided with minimum 304 stainless steel coil casing with 304 stainless steel drain pan support structure. Heating coils shall be provided with G-90 galvanized steel coil casings except in the following situations:

1. Heating coils in the preheat position in AHUs installed within 60 miles of the coast, and
2. Heating coils for all AHUs installed in the reheat position.

E. Cooling coils shall be a maximum of 8 rows and 10 fins per inch. In ASHRAE Climate Zones 1, 2, and 3, coils shall be 8 rows deep. No exceptions. Size cooling coils for minimum 80/67 EAT unless job specific conditions require more.

F. Limit the water side pressure drop on water coils to 15 feet. Limit the air side pressure drop on chilled water coils to 0.90” w.c.

G. Provide at least 18” of access between coils. Provide an easily operable access panel or door, as shown on drawings.

H. Provide coil segment casing that meets or exceeds casing performance of the unit.

I. Provide panels that are easily removable with no special tools.

J. Locate access doors to provide clearance for pipe insulation, connectors, and accessories. Space shall allow a minimum of 90 degrees of door swing.

K. Provide coils built in their own full perimeter frame. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. Casing and support members shall not block finned area.

L. Individual coils shall be removable from the side of the AHU.

M. Provide intermediate drain pans on stacked cooling coils (one at every coil break). Intermediate drain pan shall slope in a minimum of two planes toward a single drain connection.

N. Provide a single intermediate vertical coil support on coils with a finned length greater than 62”. Provide two vertical supports on coils with a finned length greater than 100” and three vertical supports on coils with a finned length greater than 141”.

O. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow draining and venting when installed. Extend vent, drain, and coil connections through AHU casing.

P. When staggered coil banks are required. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow draining and venting when installed. Vent, drain, and coil connections shall be supplied within 10” of the header. Extend vent, drain, and coil connections through AHU casing. Insulation of internal chilled water piping shall be insulated by mechanical contractor.

Q. Insulate gap between coil stub out connection and AHU casing with a spool-shaped sleeve grommet. Adhesive rings applied the casing walls are not acceptable.

R. Water and glycol coils shall be operable at 250 psig working pressure and up to 300□ F. Factory test water and glycol coils with 325 psig compressed air under water.

S. Direct expansion (DX) coils shall conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a maximum refrigerant pressure of 250 psig. Factory test DX coils with 325 psig compressed air under water. DX coils will be dehydrated and sealed prior to installation.

T. Provide water, glycol and DX coils with a tube OD of 5/8” and material thickness of 0.025”. Mechanically expand tubes to form fin bond and provide burnished, work-hardened interior surface. Turbulators shall not be permitted inside water coils.

U. Provide water coil headers made of seamless copper or brass tubing. Pipe connections shall be red brass.

V. Provide coils with die-formed, continuous aluminum fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.008” thick.

W. Provide coil coatings as scheduled or indicated on drawings.

2.15 DAMPERS

A. Provide dampers tested in accordance with AMCA 500.

B. Provide factory-installed dampers, as shown on drawings.

C. Dampers shall have airfoil blades, extruded vinyl edge seals, and flexible metal compressible jamb seals.

D. Dampers shall have a maximum leakage rate of 4 CFM/square foot at 1" w.g., and shall comply with ASHRAE 90.1.

E. Damper blades shall be opposed acting unless otherwise indicated. Parallel blades may be required to promote air mixing.

F. Damper blades shall be aluminum.

2.16 FILTERS SECTION

A. Provide filter segments with filters and frames as scheduled. Specify pre-filter racks that provide metal support on the entire perimeter of the pre-filters.

B. Provide face loading filters for all filter segment(s). Provide an 18” (minimum) access plenum and access door on the drive side through which face loading filters can be easily loaded.

C. Provide Class 2 or Class 1 filter media per U.L. 900 and as required by local codes.

D. Filter types, efficiencies, and nominal depths shall be as follows:

1. Rigid filters – 4” mini pleated with efficiencies of 60-65% (MERV 11) for all Pre-filters. 12” rigid, 90-95% (MERV 14) for final filters.

    a. Provide front loading filter tracks for all filters. Side loading racks are unacceptable.

E. Provide a flush mounted, factory installed, Magnahelic differential pressure gage on the drive side of unit to measure pressure drop across filters. Manufacturer shall provide fully functional gauges, complete with tubing.

2.17 AIR BLENDERS

A. Provide static mixing devices by Blender Products, Inc. or approved equal downstream of all outside air sections when the ASHRAE 99.6% winter design dry bulb condition is 38oF or less

to enhance the mixing of outside air with return air to an effectiveness required to eliminate freeze stat trips, minimize sensor, error and enhance outdoor air distribution.

B. The static mixer shall be capable of a minimum of 70% range mixing effectiveness when mixing 25% outside air with 75% return air at one mixer diameter downstream of mixer.

C. Multiple mixers may be utilized for OA introduced on top of air handling unit that is full casing width. All side inlet OA arrangements shall utilize single blender or minimum allowable within air handling unit casing and still provide a minimum of 70% range mixing effectiveness.

2.18 AIRFLOW MONITORING STATIONS

A. All fans shall be provided with factory mounted piezometer rings. Rings shall be factory installed in each fan inlet. The device shall have a measurement accuracy of ± 5%.

B. BAS Contractor shall provide a field-installed transducer that sends a CFM-proportional, 4-20 mA or 0-10V signal, as specified in specification section 230913.

C. Fan array measurement – For arrays having four fans or more, provide FAATS-1000 fan array airflow totalizing system by Paragon Controls or approved equal with one remote transducer per array.

2.19 HUMIDIFIER DISPERSION MANIFOLD

A. Provide Stainless Steel Short Absorption Manifold designed for atmospheric steam humidifiers or pressurized steam from a boiler, to directly inject the steam into ducted air for humidification.

B. Provide adequate vertical tube spacing to ensure absorption distance characteristic shall prevent water accumulation on any in-duct surfaces beyond 24 in downstream of the steam dispersion panel.

C. Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.

D. Provide headers of 304 stainless steel construction.

E. Provide vertical, 304 stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not accepted.

F. Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption. Systems without nozzle inserts, or other than stainless steel, are not acceptable.

G. Provide tube and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Steam header insulation is to minimize heat losses to under 10%. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. Un-insulated headers, or simple foam insulation not accepted.

2.20 ULTRAVIOLET LIGHTS

A. Provide surface decontamination UV fixtures within cooling coil sections for air handlers serving emergency departments, operating rooms, bone marrow areas, PICU, Compounding Pharmacy's and NICUs.

B. UV system shall be tied to a switch to kill power to the lighting system when the access door is opened. A second manual kill switch shall be provided inside the unit for safety.

C. UVC products shall be from an ISO 9001 manufacturer or the supplier shall provide proof of 100% inbound and outbound testing of equipment and have at least 10 years' experience as a manufacturer of UVC products for air handling equipment.

D. Fixtures shall be tested, listed and labeled as UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards: 153, 1598 & 1995 respectively.

E. Fixtures shall meet the "UL" drip proof design and each fixture is equipped with an electrical interlock.

F. Useful lamp life shall be 9000 hours with no more than a 20% output loss at the end of one year of continuous use. They are constructed with UVC proof metal bases and shall not produce ozone.

G. Each lamp shall contain no more than 8 milligrams of mercury, consistent with current environmental practices, while producing the specified output at 500 fpm in temperatures of 55-135□ F.

H. Lamps and fixtures shall be installed in sufficient quantity and in such a manner so as to provide even distribution of UVC energy on designated surface area (Coil, filter rack, etc.). When installed, the minimum intensity striking any point on a plane representing the surface of the coil or component shall not be less than 50 microwatts per square centimeter. Average radiation shall be 150 microwatts minimum per square centimeter.

I. The minimal UVC energy striking a surface shall be sufficient to continuously destroy a mono-layer of mold and bacteria as typically found in HVAC systems in less than six hours

J. Lamp fixtures shall be constructed of type 304 stainless steel to preclude corrosion. Support components shall be constructed of type 304 stainless or galvanized cold rolled steel.

K. Power supply shall be of a high efficiency, high frequency electronic type, matched to the lamp and designed to maximize UVC radiance and reliability. They shall be capable of four wire lamp operation rapid start. They shall be UL Listed and labeled, and comply with FCC 47, Part 18, non-consumer limits requirements. The ballast shall be protected from failure in the event of End of Lamp life lamp failure. The ballast shall be capable of operation indefinitely when powered with no lamp or a failed or broken lamp. Track mounted fixture ballasts shall have 120VAC or 240 VAC input. Strut mounted ballasts shall have universal input (100VAC to 277VAC). Track mounted fixtures shall be capable of producing the output as specified under Irradiation and Intensity at no more than 13Watts of power consumption for each square foot of treated, cross sectional plane.

L. Ballast system shall not proprietary to the manufacturer of the UV bulb.

M. Provide and install a UV radiometer for monitoring bulb intensity near center of coil - tie to BAS. Set BAS to alarm operator when bulb intensity drops below manufacturer-recommended threshold.

N. Original purchase of equipment has to include service contract to replace bulbs once per year for five years after startup. Contract must include materials and labor to install new and dispose of old bulbs.

2.21 APPURTENANCES

A. For motors 7.5HP and larger in the stacked position, provide internal structural I-Beam motor removal rail with structural frame to distribute motor weight to unit base. Rail shall be perpendicular to centerline of access door for ease of removal.

B. Provide rain hoods on outdoor unit air intakes, as shown on drawings. Provide moisture screens on outdoor air inlet rain hoods.

C. Provide steel base rails suitable for rigging and lifting, as shown on product drawings.

D. Provide safety grates over bottom openings, as shown on drawings.

E. Safety grates shall be capable of supporting a 300 lb. center load.

F. Provide lifting lugs where required.

2.22 FINISHES

A. Manufacturer shall clean the exterior surfaces of units prior to finishing, painting, or shipment.

B. Unpainted air-handling units constructed of galvanized steel shall pass the ASTM B-117 test for 220-hour salt spray solution (5%) without any sign of red rust. (confirm)

C. Manufacturer shall paint outdoor units prior to shipment. Manufacturer shall paint indoor units, as scheduled or shown on drawings.

1. Manufacturer shall apply a primer prior to painting units.
2. Manufacturer shall apply a finish coat of acrylic polyurethane paint.

3. Finished unit shall exceed 500-hour salt spray solution (5%) test without any sign of red rust when tested in accordance with ASTM B-117.

2.23 TESTS AND INSPECTIONS

A. Manufacturer shall dynamically balance fan/motor/base assembly.
   1. Balance constant volume fan assemblies at design RPM.
   2. Balance variable volume fan assemblies from 10% to 100% of design RPM.
   3. Take filter-in measurements in the horizontal and vertical axes on the drive and opposite-drive sides of fan shafts.
   4. Constant speed fan vibration limits: filter-in measurements shall not exceed 4 mils.
   5. Variable speed fan vibration limits: filter-in measurements shall not exceed 7 mils.

B. Manufacturer shall hi-pot test wiring intended to carry voltages greater than 30VAC.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which air handling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION, GENERAL

A. Install equipment per industry standards, applicable codes, and manufacturer's instructions.

B. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.

C. Install rooftop AHUs on a roof curbs, as shown on drawings. To reduce the potential for noise complaints, retain the maximum amount of roof mass under the unit and locate rooftop units over non-sound sensitive area. Where possible, cut openings in roof for duct and pipe penetrations – do not open roof to entire area under curb. Provide sound plenums within building to reduce sound transmission. Sound plenum construction shall be thoroughly detailed.

D. Install all AHUs on elevated slabs not over a mechanical room on floating floor arrangement per HCA standard detail.

E. Install AHUs with manufacturer's recommended clearances for access, coil pull, and fan removal.

F. Install AHU plumb and level. Connect piping and ductwork according to manufacturer's instructions.

G. Install seismic restraints and anchors per applicable local building codes. Refer to specification Section 230548 (15240 / 15070) for product and installation requirements.

H. Install pipe chases per manufacturer's instructions.

I. Insulate plumbing associated with drain pan drains and connections. Run condensate to nearest floor drain or roof drain.

J. Install insulation on all staggered coil piping connections, both internal and external to the unit.

K. If access to the interior of the air handler for maintenance and repair cannot be gained without a ladder, a permanent access ladder must be provided. Install platforms and access ladders to permit full maintenance of the upper level of stacked air handlers. Platform and support structure shall not obstruct door swing, coil pull, and other reasonable maintenance access to the lower level.

L. Store per AHU manufacturer's written recommendations. Store AHUs indoors in a warm, clean, dry place where units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will be stored for more than 6 months, follow manufacturer's instruction for long-term storage.

M. Rig and lift units according manufacturer's instructions.

3.03 CONNECTIONS

A. 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. Arrange piping installations adjacent to units to allow unit servicing and maintenance.
2. Connection piping to air-handling units with flexible connectors.
3. Connect water supply piping to the air leaving side of water coils.
4. Route unit condensate drain piping to location shown on the plan or, if not shown, to the nearest equipment or floor drain. Construct deep trap, minimum of 1" deeper than fan pressure in inches of water, at connection to drain pan and install cleanouts at changes in direction. Size condensate drain piping in accordance with local code and the following:

Piping Length	Size
Less than 10 feet	Same size as unit connection
More than 10 feet	One pipe size larger than unit connection

B. Duct installations and connections are specified in other Division 23 sections. Make final duct connections with flexible connections.

C. Electrical Connections: The following requirements apply:

1. Electrical power wiring is specified in Division 26.
2. Temperature control wiring and interlock wiring is specified in Division 23 section “Direct-Digital Control for HVAC.”

D. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.04 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust water coil flow, with control valves to full coil flow, to indicated gpm.

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.

3.05 STARTUP

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Comply with manufacturer’s start-up requirements to ensure safe and correct operation and integrity of warranty.

C. 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 zone dampers to full open for each zone.
7. Set face-and-bypass dampers to full face flow.
8. Set outside-air and return-air mixing dampers to minimum outside-air setting.

9. Comb coil fins for parallel orientation.
10. Install clean filters. Do not operate air handling unit without pre-filters installed.
11. Verify manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in the full-open position.
12. Disable automatic temperature control operators.

D. Start-Up Procedures: Start-up air-handling units in accordance with manufacturer's written start-up instructions and as specified herein. 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 air-handling-system testing, adjusting, and balancing.

3.06 AHU INSPECTION

A. Installing Contractor to perform an inspection of unit and installation prior to startup. Start-up report submitted to general contractor shall verify the following as a minimum:

1. Damage of any kind
2. Level installation of unit
3. Proper reassembly and sealing of unit segments at shipping splits.
4. Tight seal around perimeter of unit at the roof curb
5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
6. Completion and tightness of electrical, ductwork and piping
7. Tight seals around wiring, conduit and piping penetrations through AHU casing.
8. Supply of electricity from the building’s permanent source
9. Integrity of condensate trap for positive or negative pressure operation
10. Condensate traps charged with water
11. Removal of shipping bolts and shipping restraints
12. Sealing of pipe chase floor(s) at penetration locations.
13. Tightness and full motion range of damper linkages (operate manually)
14. Complete installation of control system including end devices and wiring
15. Cleanliness of AHU interior and connecting ductwork
16. Proper service and access clearances
17. Proper installation of filters
18. Filter gauge set to zero

B. Resolve any non-compliant items prior to unit start-up.

3.07 INSPECTION AND ADJUSTMENT: AHU FAN ASSEMBLY

A. Hire the manufacturer’s factory-trained and factory-employed service technician perform an inspection of the AHU fan assembly subsequent to general AHU inspection and prior to startup. Technician shall inspect and verify the following as a minimum:

1. Fan isolation base and thrust restraint alignment
2. Tight set screws on pulleys, bearings and fan
3. Tight fan bearing bolts
4. Tight fan and motor sheaves

5. Tight motor base and mounting bolts
6. Blower wheel tight and aligned to fan shaft
7. Sheave alignment and belt tension
8. Fan discharge alignment with discharge opening
9. Fan bearing lubrication
10. Free rotation of moving components (rotate manually)

3.08 TRAINING

A. Manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Technician shall perform the following steps as a minimum:
   1. Energize the unit disconnect switch
   2. Verify correct voltage, phases and cycles
   3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
   4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
   5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.

B. Provide a minimum of 4 hours of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician. Training shall include AHU controls, motor starter, VFD, and AHU.

C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.

D. If AHU is provided with a factory-mounted variable frequency drive (VFD), hire the VFD manufacturer's factory-trained and factory-authorized service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.

E. If AHU is provided with a factory-mounted humidifier, hire the humidifier manufacturer's factory-trained and factory-authorized service technician to inspect, test, adjust and verify proper operation in conjunction with BAS contractor.

F. Submit a startup report summarizing any problems found and remedies performed.

G. Permanent air handling equipment shall not be started under any circumstances until dust-generating construction activities such as drywall sanding and floor grinding are complete and the space is entirely cleaned. Until that time, the air handler shall be properly sealed to eliminate dust collecting inside the unit.

3.09 CLEANING

A. Clean unit interior prior to operating. Remove tools, debris, dust and dirt.

B. Clean exterior prior to transfer to owner.

3.10 DOCUMENTATION

A. Provide Installation Instruction Manual, & Startup checklist in the supply fan section of each unit.

B. Provide six copies of Spare Parts Manual for owner's project system manual.

END OF SECTION 23 73 13

SECTION 23 84 13
HUMIDIFIERS (DISPERSION TYPE)

PART 1 - GENERAL

1.01 SUMMARY

A. Scope: Extent of humidifier work required by this Section is indicated on the drawings and schedules, and by requirements of this Section, and Division 23 Section "General Mechanical Requirements."

B. Types: Types of humidifiers specified in this Section include:
   1. Steam Jacket Dispersion Tube Humidifiers.
   2. Steam Injection Humidifier with Dispersion Tube Panel.
   3. Packaged Vertical Dispersion Tube.

C. Packaged Systems: Humidifiers furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 Sections.

D. Refer to other Division 23 Sections for:
   1. Metal Ducts
   2. Direct-Digital Control for HVAC
   3. HVAC Insulation
   4. Testing, Adjusting and Balancing for HVAC

E. Refer to Division 26 Sections for power wiring and disconnects.

1.02 QUALITY ASSURANCE

A. Codes and Standards: Provide humidifiers conforming to the following standards:
   1. Underwriters Laboratories, Inc. (UL) or Electrical Testing Laboratories (ETL): Provide electric humidifiers with UL or ETL label and listing.

B. Certification: Provide humidifiers whose performances, under specified operating conditions, are certified by the manufacturer.

1.03 SUBMITTALS

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

   1. Product Data: Submit manufacturer's humidifier specifications, installation and start-up instructions, and current humidifier performance information with selection points clearly indicated.

2. Shop Drawings: Submit manufacturer’s shop drawings indicating dimensions, required clearances and methods of assembly of components.

3. Wiring diagrams detailing wiring for power and controls and differentiating between manufacturer-installed wiring and field-installed wiring.

4. Maintenance data for humidifiers, for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 23 Section "General Mechanical Requirements."

1.04 DELIVERY, STORAGE AND HANDLING

A. Delivery: Handle humidifiers carefully to prevent damage, denting and scoring. Do not install damaged humidifiers or components; replace with new.

B. Storage: Store humidifiers and components in a clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Steam Jacket Dispersion Tube Humidifiers

1. Armstrong Intl., Inc.
2. Dri-Steem Humidifier
3. Neptronic
4. Nortec Industries

B. Steam Injection Humidifier with Dispersion Tube Panel

1. Armstrong Intl., Inc.
2. Dri-Steem Humidifier
3. Hygromatik, Div. Of Spirax Sarco
4. Neptronic
5. Nortec Industries
6. Pure Humidifier Co.

C. Packaged Vertical Dispersion Tube Pane

1. Armstrong Intl., Inc.
2. Dri-Steem Humidifier
3. Neptronic
4. Nortec Industries

2.02 GENERAL

A. Humidifiers: Provide factory fabricated humidifiers of arrangements and capacities indicated. Water atomizing humidifiers shall not be used.

2.03 STEAM JACKETED DISPERSION TUBE HUMIDIFIERS

A. Type: Provide duct or air handling unit mounted humidifiers with steam jacketed dispersion tubes, condensate separators and automatic control valves.

B. Dispersion Tubes: Provide dispersion tubes as follows:

1. Provide dispersion tubes designed to evenly distribute the specified quantity of steam uniformly over the entire cross section of the air stream.

2. Provide single or multiple dispersion tube manifolds as required to achieve total steam absorption in a steam travel distance or 3 feet or less.

3. Provide dispersion tubes designed so that steam passes in the jacket around the dispersion tube to superheat the steam in the dispersion tube and re-evaporate any moisture present to ensure dry steam is discharged into the air stream.

4. Construct dispersion tubes and steam jackets of 304 stainless steel.

5. Provide sound absorbing material to muffle steam noise. Sound absorbing material in contact with steam or condensate shall be stainless steel.

6. Provide insulated dispersion tubes and manifolds for all humidifiers installed in dual duct and multizone systems. Insulate the tubes with 1/2-inch fiberglass. Provide type 304 stainless steel, 22 gauge jacket over insulation.

C. Condensate Separator: Provide condensate separator as follows:

1. Provide cast iron or 304 stainless steel condensate separators to remove moisture from steam prior to entering dispersion tube.

2. Provide a float and thermostatic or inverted bucket trap to drain condensate from separator.

D. Automatic Control Valve: Provide automatic control valve as follows:

1. Provide a modulating automatic control valve with modified linear control characteristics, selected by the manufacturer of the humidifier to match the capacity of the humidifier.

2. Provide automatic control valves with bronze or cast iron bodies and bronze or stainless steel trim.

3. Provide modulating electric or pneumatic valve actuators compatible with other control system components specified under Division 23.

2.04 STEAM INJECTION HUMIDIFIER WITH DISPERSION TUBE PANEL

A. Type: Provide duct or air handling unit mounted humidifiers with dispersion tube panel, condensate separators and automatic control valves.

B. Condensate Separator: Provide condensate separator as follows:

1. Provide cast iron or 304 stainless steel, centrifugal type condensate separators to remove moisture from steam prior to entering dispersion tube panel.

2. Provide a float and thermostatic or inverted bucket trap to drain condensate from separator.

C. Automatic Control Valve: Provide automatic control valve as follows:

1. Provide a normally closed, modulating automatic control valve with modified linear control characteristics, selected by the manufacturer of the humidifier to match the capacity of the humidifier.

2. Provide automatic control valves with bronze or cast iron bodies and stainless steel parabolic type plug and stainless steel trim.

3. Provide electronic valve actuators compatible with other control system components specified under Division 23 Section “Instrumentation and Control Devices for HVAC.”

D. Dispersion Tube Panel: Provide dispersion tube panel as follows:

1. Provide horizontal header and vertical dispersion tube panel designed to evenly distribute the specified quantity of steam uniformly over the entire cross section of the air stream. Vertical headers are not allowed.

2. Provide multiple dispersion tubes as required to achieve total steam absorption in the steam travel distance as scheduled on the drawings.

3. Construct headers and dispersion tubes and steam jackets of 304 stainless steel. Provide stainless steel steel casing for duct-mounted humidifiers.

4. Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption. Systems without nozzle inserts are not allowed.

5. Provide tube and header insulation constructed from 304 stainless steel shielding. Steam header insulation shall be as required to minimize heat losses to under 10%. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. Un-insulated headers, or simple foam insulation not accepted**.** Provide sound absorbing material to muffle steam noise. Sound absorbing material in contact with steam or condensate shall be stainless steel.

6. Steam and condensate pipe connections shall be on the same side of the unit.

2.05 PACKAGED VERTICAL DISPERSION TUBE PANEL

A. Humidifier shall consist of an air handling unit mounted or duct mounted, packaged vertical dispersion panel, pressurized steam supply, sloped condensate collection header, automatic control valve, and vertical steam dispersion tubes.

B. Steam dispersion vertical tubes and horizontal headers shall be Type 304 stainless steel. Vertical headers are not allowed. Tubes shall be insulated with a closed-cell insulation. The steam header shall be insulated with 1/2" rigid acrylic polymer coated fiberglass. Insulation shall meet NFPA requirements. Provide welded joints and gaskets for the tubes. Dispersion tubes shall be designed so that steam passes in the jacket around the dispersion tube to superheat the steam in the dispersion tube and re-evaporate any moisture present to ensure dry steam is discharged into the airstream.

C. Provide sound absorbing material to muffle steam noise. Sound absorbing material in contact with steam or condensate shall be stainless steel.

D. The panel casing shall be contained within a galvanized steel casing to allow for installation inside of the AHU.

E. Distribution manifold shall distribute steam over the entire cross-section of the AHU. Provide all manifold supports for a complete installation. The bottom of the manifold shall be installed a minimum 1’-0” off the AHU floor. The maximum vapor trail shall be limited to 1’-6”.

F. Provide with an electric operated steam control valve with spring return for normally closed operation and solenoid valve. Valve shall include stainless steel trim and electric actuator. Coordinate voltage with the controls contractor.

G. Provide electric temperature switch to prevent humidifier operation until the start-up condensate is drained and the humidifier is at temperature.

H. Humidifier shall include float and thermostatic trap and inverted bucket trap to allow for condensate lift. Coordinate capacities and pressures with the scheduled information in the specifications.

I. High humidity limit switch, manual reset, adjustable set-point, and NEMA 1 enclosure, shall be provided by the Controls Contractor and shall be wired to defeat the humidifier.

J. Humidifier manifold shall be installed by the AHU manufacturer at the factory. Provide all supports where required by the humidifier manufacturer.

K. Steam and condensate connections shall be on same side of unit.

L. Steam and Condensate piping shall be routed through the piping vestibule roof curb area and into the humidifier section of AHU casing for connection in field by others. All steam and condensate piping necessary to connect multiple distribution manifolds within the unit shall be provided by unit manufacturer. Refer to AHU layout for the piping locations.

M. Provide an electric operated solenoid valve, two-position, normally closed, solenoid operated and on-off steam valve.

N. Provide a modulating automatic control valve with modified linear control characteristics, selected by the manufacturer of the humidifier to match the capacity as scheduled. Valve shall be bronze or cast-iron body, bronze or stainless steel trim and include end switch. Coordinate electric valve actuator with the facility DDC contractor.

O. Provide in-line Y-pattern strainer for installation at the inlet to the electric steam control valves.

2.06 ACCESSORIES:

A. General: Provide accessories with humidifiers as follows:

1. Provide high limit duct humidistat to shut down humidifier on sensing of high humidity level to protect against saturation of duct airstream.

2. Provide electric type airflow proving switch to lock out humidifier when no airflow is sensed.

3. Provide temperature switch to prevent cold startup of humidifier.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install humidifiers in accordance with the manufacturer’s instructions and in an arrangement that will permit access and ease of maintenance.

B. Steam and condensate piping: Provide piping as indicated including unions, strainers, steam traps, dirt legs and shutoff valves.

C. Water piping: Provide piping as indicated including unions, shutoff valves, strainers and pressure regulating valves.

D. Drain Piping: Provide drain piping as indicated including unions and traps and run to nearest floor drain.

3.02 FIELD QUALITY CONTROL

A. Provide the services, to include a written report, of a factory authorized service representative to supervise the field assembly of the components, installation, and piping and electrical connections.

3.03 DEMONSTRATION

A. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate proper operation of equipment, accessories and controls.

3.04 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 four 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 "Operation and Maintenance Data."

4. 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.

C. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION 238413

SECTION 26 00 10
GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section and to all following sections within Division 26.

1.02 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.

1.03 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.
6. Contract Administrator: The primary liaison between the Owner and the Contractor. When used in this Division it means "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.

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. 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.

1.04 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
AIA	Guidelines for Design and Construction of Hospital and Healthcare Facilities
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.

1.05 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. Provide materials with trim that will fit properly the types of ceiling, wall, or floor finishes actually installed.

E. 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.

F. 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.

1.06 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 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.

1.07 SUBMITTALS

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

B. Submittals and shop drawings shall not contain HEI's firm name or logo, nor shall they contain the HEI engineer's seal and signature. They shall not be copies of HEI's work product. If the Contractor desires to use elements of such product, the license agreement for transfer of information at the end of this Section 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. 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 Contract Administrator, plus a duplication of this time for resubmittals, if required. Transmit submittals as soon as possible after Notice to Proceed and before Electrical 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 Contract Administrator 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 Contractor Administrator's 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 Contract Administrator 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 Contract Administrator prior to implementing any deviation.

1.08 SUBSTITUTIONS

A. Refer to Division 1 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.

1.09 ELECTRONIC DRAWING FILES

A. In preparation of shop drawings or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF 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 Architect for Architect's written authorization.

D. The following must be received before electronic drawing files will be sent:

1. Architect'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 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 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 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 Contract Administrator 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 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. 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.

1.17 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. Relocate and reconnect electrical facilities that must be relocated in order to accomplish the remodeling shown in the Drawings or indicated in the Specifications. Where electrical equipment or materials are removed, cap unused raceways below the floor line or behind the wall line to facilitate restoration of finish.

6. Finish material will be installed under other Divisions.

7. Obtain permission from the Contract Administrator for channeling of floors or walls not specifically noted on the Drawings.

8. 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.
9. 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. Use of explosives is not permitted.

C. 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

3.01 INSTALLATION, GENERAL

A. Install all products and materials in accordance with manufacturer's instructions.

3.02 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.

3.03 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. Contractor shall maintain contingency work plans should Owner be required to alter allowable working hours on short notice or require Contractor to cease work as previously

described. Contractor contingency plan shall allow efficient use of their personnel in other areas or perform other portions of the Work when Owner exercises the right to deny Contractor access to specific areas. Additional payment to the Contractor will not be allowed as a result of Owner's denial of access to areas within the Facility.

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. Channel walls and floors as required to produce the desired result; however, obtain permission from the Contract Administrator for all 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.

3.04 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.

3.05 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. The Owner will pay all charges made by the Electrical 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.

3.06 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.

3.07 ACCESS TO EQUIPMENT

A. Locate all pull boxes, junction boxes and controls so as 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.

3.08 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.

3.09 CUTTING AND PATCHING

A. Provide all necessary cutting of walls, floors, ceilings and roofs for work under this Division.

B. Cut no structural member without permission from Contract Administrator.

C. Patch around all openings to match adjacent construction.

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

3.10 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.

3.11 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 final inspection, make a final cleanup of dirt and refuse resulting from Work and assist in making the premises broom clean. Clean all material and equipment installed under this Division.

C. Remove dirt, dust, plaster, stains, and foreign matter from all surfaces.

D. Touch up and restore damaged finishes to their original condition.

3.12 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.

3.13 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.

3.14 TEST REPORTS

A. Perform tests as required by these Specifications and submit the results 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.

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. Voltages (phase-to-phase and phase-to-neutral) and amperes at each phase for each panelboard, switchboard, and the like.
2. Phase voltages and amperes at each three-phase motor.
3. Test all wiring devices for electrical continuity and proper polarity of connections.

D. Promptly correct all failures or deficiencies revealed by these tests as determined by the Engineer.

3.15 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 26 00 10

SECTION 26 00 15
ELECTRICAL MATERIALS PURCHASING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section falls under the guidelines established in HCA Innovation Memo #16 – Electrical Materials. If conflicts exist between the information here included and the guidelines established by the Innovation Memo, the Innovation Memo is to take precedent.

B. Existing manufactured gear does not preclude the partnering vendors listed above from providing an “as equal” solution for consideration and evaluation. Partner manufacturers for power switchgear/power are Eaton and Schneider.

C. If products needed or required are not available under the agreement they will be identified by the engineer of record and may be procured through traditional channels. Contact engineer of record and/or HCA engineering for questions and clarifications.

1. Pricing and Purchasing of materials described under the following specification sections is to be through either or both of CED-Nashville and Graybar-Nashville.

a. CED-Nashville; 330 19th Ave. North – Nashville, TN – 37203; Attn: Lance Smith; HCA@ced-nashville.com; (615) 329-2601 or (615) 207-7223
b. Graybar-Nashville; 825 8th Ave. South – Nashville, TN – 37217; Attn: Jess Hoover; HCA@graybar.com; (615) 743-3232 or (239) 494-2088

260500 COMMON WORK RESULTS FOR ELECTRICAL
260502 EQUIPMENT WIRING SYSTEMS
260510 COMMON WORK FOR COMMUNICATIONS (NON-COLLECTIVE TECH)
260519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
260529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
260533 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
260553 IDENTIFICATION FOR ELECTRICAL SYSTEMS
260573 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY
260923 LIGHTING CONTROL DEVICES
262200 LOW-VOLTAGE TRANSFORMERS
262416 PANELBOARDS
260543 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
262726 WIRING DEVICES
262813 FUSES
264313 SURGE PROTECTIVE DEVICES
265100 INTERIOR LIGHTING
265600 EXTERIOR LIGHTING

END OF SECTION 26 00 15

SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 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. Electrical equipment nameplate data.
3. Sleeves and seals for electrical penetrations.
4. Joint sealers for sealing around electrical materials and equipment, and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
5. Sealing penetrations through noise critical spaces.

1.02 DEFINITIONS

A. The following abbreviations apply to this and other Sections of these Specifications:

1. AFF: Above Finished Floor
2. AHJ: Authority(ies) having Jurisdiction
3. ATS: Acceptance Testing Specifications
4. EMT: Electrical Metallic Tubing
5. EPDM: Ethylene-propylene-diene monomer rubber
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. MC: Metal Clad
12. MFR: Manufacturer
13. N/A: Not Available or Not Applicable
14. NBR: Acrylonitrile-butadiene rubber
15. NRTL: Nationally Recognized Testing Laboratory
16. PCF: Pounds per Cubic Foot
17. RAC: Rigid Aluminum Conduit
18. RMC: Rigid Metal Conduit
19. RNC: Rigid Nonmetallic Conduit

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.

1.03 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 with general contractor to provide at least one path to outside with 8'-0" tall door in main electrical rooms and generator rooms that contain switchgear, motor control centers, generators and other electrical equipment taller than 6'-6".

C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

D. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

E. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.04 NOISE CRITICAL SPACES

A. Many areas of the building, referred to as "noise-critical spaces", require special attention (special acoustical provisions and restrictions). The table below designates the noise-critical spaces that will require application of sound attenuating measures and acoustical sealants.

1. Patient and Baby Care Areas
2. Offices
3. Consultation Rooms
4. Operating Rooms
5. Procedure Spaces
6. Exam Rooms

1.05 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section "General Electrical Requirements":

1. Submit dimensioned layouts of electrical equipment locations within electrical rooms, generator rooms and fire pump rooms with equipment drawn to ¼" scale and identified therein. Working clearance and access shall be clearly identified on the drawings. Rooms shall be designed, including door openings, and clearance shall be provided to allow for the future removal of each generator, unit substation transformer or other large piece of equipment independently without having to remove non-related equipment first.
2. Product data for the following products:
    a. Sleeve seals.
    b. Through and membrane penetration firestopping systems.
    c. Joint Sealers
    d. Acoustical sealers
3. Shop drawings for:
    a. Detailed fabrication drawings of access panels and doors.
4. Detailed list of proposed nameplates for Owner/Engineer review and acceptance before fabrication and attachment.
5. 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.

6. Record Drawings: Submit Record Drawings as required by Division 1 and Division 26

a. Accurately record actual locations of firestopped penetrations and access panel/door locations. Indicate dimensions from fixed structural elements.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

B. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference.

2.02 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: Flush, screwdriver-operated cam locks.

2.03 STEEL SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends and drip rings.

2.04 CAST IRON WALL PIPE SLEEVES FOR RACEWAYS AND CABLES

A. Manufacturers
1. Josam Mfg. Co.
2. Smith (Jay R) Mfg. Co.
3. Tyler Pipe/Wade Div.; Subs of Tyler Corp.
4. Watts Industries, Inc.
5. Zurn Industries, Inc.; Hydromechanics Div.

B. Cast-iron sleeve with integral clamping flange with clamping ring, and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with setscrews.

C. Sleeves for rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138- inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping to be used.

2.05 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 Contract Administrator 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.
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, 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.
3. Products: Subject to compliance with requirements, provide one of the following:
a. One-Part, Nonacid-Curing, Silicone Sealant:
1) "Dow Corning 790," Dow Corning Corp.
2) "Dow Corning 795," Dow Corning Corp.
3) "Silglaze N SCS 2801," General Electric Co.
4) "Silpruf SCS 2000," General Electric Co.
5) "864," Pecora Corp.
6) ."Omniseal," Sonneborn Building Products Div
7) "Spectrem 1," Tremco, Inc.
8) "Spectrem 2," Tremco, Inc.
b. One-Part, Mildew-Resistant, Silicone Sealant:

1) "Dow Corning 786," Dow Corning Corp.
2) "Sanitary 1700," General Electric Co.
3) "898 Silicone Sanitary Sealant," Pecora Corp.
4) "OmniPlus," Sonneborn Building Products Div.
5) "Tremsil 600 White," Tremco Corp.

D. Acrylic-Emulsion Sealants: One-part, non-sagging, 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.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. "Chem-Calk 600," Bostik
      b. "AC-20," Pecora Corp.
      c. "Sonolac," Sonneborn Building Products Div.
      d. "Tremflex 834," Tremco, Inc.

2.06 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, by Underwriters' Laboratories, Inc., or other NRTL acceptable to AHJ.
   1. Manufacturers:
      a. Hilti, Inc.
      b. RectorSeal.
      c. Specified Technologies Inc.
      d. 3M Corp.
      e. United States Gypsum Company.

2.07 ACOUSTICAL SEALANTS

A. Foam Backer Rod: Closed cell polyethylene suitable for use as a backing for non-hardening sealant.

B. Non-Hardening Penetration Sealant: Non-hardening polysulphide type. Permanently flexible, approved firestop putty may be used in lieu of the sealant on foam rod in noise critical walls that are also fire rated.

C. Packing Material: Mineral fiber; non-combustible; resistant to water, mildew and vermin. Expanding resilient foams manufactured for this purpose are an acceptable alternative only if the material density is at least 15 PCF (40 kg/m3).

PART 3 - EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

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. Comply with NECA 1.

D. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless indicated otherwise.

E. 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.

F. 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.

G. Right of Way: Give to raceways and piping systems installed at a required slope.

3.02 ACCESS DOORS

A. Furnish adequately sized access doors for the devices served, with a minimum size of 18 inches x 18 inches, for installation under Division 09 “Finishes”.

B. Furnish access doors of the proper construction for type of ceiling or wall construction where installed.

C. Verify the exact location, sizes, and types of all access doors with the Contract Administrator prior to purchase.

D. Provide access doors for all concealed electrical equipment, except where above lay-in ceilings.

E. 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.

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

G. Label all access doors with a nameplate as described in Division 26 Section “Identification for Electrical Systems”.

3.03 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 all 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. 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 Contract Administrator, Owner, or both. Seal sleeves and sleeve seals into concrete walls or slabs with a waterproof non-shrink grout acceptable to the Contract Administrator.

E. 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.

F. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

G. 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.

H. 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.

I. 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.

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

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

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. 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.

Q. 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 with the following minimum metal thickness:
        1) For sleeve cross-section rectangle perimeter 50 inches and no side greater than 16 inches, thickness shall be 0.52 inches.
        2) For sleeve cross-section rectangular perimeter equal to, or greater than, 50 inches and one (1) or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inches.
    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.

R. 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.

S. 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.

T. 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.

U. 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.

3.04 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire/smoke-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.05 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 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.

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.

3.06 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 26 05 00

SECTION 26 05 02
EQUIPMENT WIRING SYSTEMS

PART 1 - GENERAL

1.01 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.

1.02 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 22 Section “Medical Gas Systems”.

C. Coordinate with work described in 23 Section, “Common Work Results for HVAC”.

D. Coordinate with work described in Division 23 Section “Direct-Digital Control for HVAC”.

E. Obtain and review shop drawings, product data, and manufacturer's instructions for equipment furnished under other sections.

F. Determine connection locations and rough-in requirements based on Shop Drawings.

G. Sequence rough-in of electrical connections to coordinate with installation schedule for equipment.

H. Sequence electrical connections to coordinate with start-up schedule for equipment.

1.03 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 for:
    a. Special connectors
    b. Special conductors or cable assemblies
2. Shop drawings for:
    a. Detailing electrical characteristics, wiring diagrams, fabrication and installation for wiring systems.

1.04 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.

PART 2 - PRODUCTS AND MATERIALS

2.01 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

3.01 EXAMINATION

A. Verify conditions of equipment and installation prior to beginning work.

B. Verify that equipment is ready for connecting, wiring, and energizing.

3.02 INSTALLATION, GENERAL

A. Install in accordance with manufacturer's instructions.

3.03 ELECTRICAL DEVICES

A. Install disconnect switches, controllers, control stations, and control devices (other than temperature control devices) as indicated.

B. Install disconnect switches, controllers, control stations, and control devices (other than temperature control devices) specified in other Divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.

3.04 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.

3.05 HVAC 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.

3.06 DOOR OPERATORS AND HARDWARE

A. Provide electrical connections to automatic entry doors, automatic corridor doors, electrically held door latches, remote release doors, and all other required electrical connections for door systems included in other sections of these specifications.

B. Provide power connection to all equipment as required and as indicated in the equipment supplier's installation drawings.

C. Provide all control wiring and conduit for all equipment that is not included within the responsibility of the door hardware installer. Provide connection from junction boxes to the door operators or hardware and from door operators to actuation devices as required. Install key operated switches, push pad switches, and other electrically controlled door operation devices furnished by other divisions within this contract.

D. Provide fire alarm devices and wiring as required for proper operation of door systems in accordance with the NFPA codes.

3.07 MEDICAL GAS SYSTEMS

A. All connections associated with the medical gas system shall be made in accordance with NFPA 99 – Standard for Healthcare Facilities.

B. Provide power connection to all equipment as indicated or as otherwise required to accommodate the equipment indicated in the medical gas system drawings and specifications.

C. Provide all raceways, conduit, back boxes and cabling for all control wiring required to accommodate the equipment indicated in the medical gas system drawings and specifications, that is not indicated as being within the responsibility of the equipment installer.

D. Provide all grounding systems as required by the equipment supplier.

3.08 MEDICAL EQUIPMENT

A. Provide all work related to Division 26 required for the Owner furnished medical equipment. Note that this work has not been entirely duplicated and indicated on the sheets with E prefixes, rather only a minimum amount as required for coordination with other systems, and as required to comply with local codes. The medical equipment planner has prepared a complete manual including all the equipment intended to be purchased general electrical requirements and associated cut sheets. Review the medical equipment manual prior to bid. Prior to rough-in and final connection coordinate with final equipment installation diagrams, drawings, manuals, and specifications. Such equipment may include but shall not be limited to the following: mobile x-ray equipment, surgical or exam lights, articulating arms, equipment booms, headwalls, patient beds, patient lift systems, processors, sterilizers, warming cabinets, refrigerators, freezers, blood bank equipment, laboratory equipment, x-ray film view boxes, digital x-ray viewing systems, or bio-medical patient monitoring systems.

B. Provide power connection to all equipment as indicated or as otherwise required to accommodate the medical equipment.

C. Provide all grounding systems as required by the equipment supplier.

D. Provide wireways, cable trays, trench duct, wall duct, conduit and all other raceways and boxes as required to accommodate the medical equipment that is not indicated as being within the responsibility of the equipment installer.

E. Provide all other equipment, wiring, connections, emergency power off stations, warning lights, interlocks, controls, etc. as required to accommodate the medical equipment that is not indicated as being within the responsibility of the equipment installer.

3.09 DIAGNOSTIC AND THERAPEUTIC MEDICAL IMAGING EQUIPMENT

A. Provide all work related to Division 26 required in the medical equipment installation drawings. Note that this work has not been entirely duplicated and indicated on the sheets with E prefixes, rather only a minimum amount as required for coordination with other systems, and as required to comply with local codes. Typically the medical equipment installation drawings are attached to the construction drawing set, however some vendors issue a separate installation manual in book format. Review all medical equipment installation drawings, manuals, and specifications prior to bid and rough-in. Such equipment may include but shall not be limited to the following: x-ray equipment, catheterization lab equipment, linear accelerator equipment, simulator equipment, CT scan equipment, MRI equipment, surgical room lights and equipment, and other diagnostic and therapeutic equipment.

B. Provide power connection to all equipment as indicated or as otherwise required to accommodate the medical equipment.

C. Provide all grounding systems as required by the equipment supplier.

D. Provide wireways, cable trays, trench duct, wall duct, conduit and all other raceways and boxes as required to accommodate the medical equipment that is not indicated as being within the responsibility of the equipment installer.

E. Provide all other equipment, wiring, connections, emergency power off stations, warning lights, interlocks, controls, etc. as required to accommodate the medical equipment that is not indicated as being within the responsibility of the equipment installer.

3.10 SMOKE EVACUATION

A. Life Safety feeders shall be installed in fire rated enclosures or shall be constructed as a rated assembly per NEC700 and IBC 403.

B. Life Safety feeders shall not be routed in the same enclosures as other feeder types except as permitted by NEC 700.

C. Life Safety loads shall be as defined by NEC 700 and IBC 403 including but not limited to the following:

1. Egress Lighting
2. Smoke Evacuation Fans
3. Stair Pressurization Fans
4. Atrium Ventilation Fans

END OF SECTION 26 05 02

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes:
   1. Conductors, cables, and cords rated 600V and less.
   2. Connectors and terminations rated 600V and less.

1.02 DEFINITIONS

A. The following abbreviations apply to this and other Sections of these specifications:
   1. MC: Metal Clad
   2. NBR: Acrylonitrile-butadiene rubber

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. 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.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.

1.04 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 – Health Care Facility (MC-HCF) and fittings.

B. Qualification Data: For testing agency.

C. Field Quality-Control Test Reports:
   1. Submit all system and component test results.

1.05 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 an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to AHJ.

D. 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.

E. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

B. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference.

2.02 CONDUCTORS AND CABLES

A. General
   1. Manufacturers:
      a. AFC Cable Systems, Inc.
      b. Alan Wire
      c. Cerrowire
      d. Colonial Wire & Cable
      e. Encore Wire Corporation
      f. General Cable
      g. Northern Cables Inc.
      h. Okonite Company
      i. Southwire Company
   2. Conductor Material: Annealed (soft) copper complying with ICEA S-95-658/NEMA WC70 and UL Standards 44 or 83, as applicable;
      a. Stranded conductors
      b. Solid conductors for No. 10 AWG and smaller; concentric, compressed stranded for No. 8 AWG and larger
      c. Stranded for all flexible cords, cables, and control wiring
      d. As noted otherwise below
   3. Aluminum conductors are not allowed.
   4. Conductor Insulation: Complying with ICEA S-95-658/NEMA WC70 use Type:
      a. THW
      b. THHN/THWN-2
      c. XHHW-2
   5. Sizes of conductors and cables indicated or specified are American Wire Gage (Brown and Sharpe).
   6. 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.
   7. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

2.03 SINGLE CONDUCTORS

A. 600V, insulated conductors as noted above shall be color-coded as follows:

PHASE	120/240V	240Δ/120V	208Y/120V	480Y/277V
A	Black	Black	Black	Brown
B	Red	Orange	Red	Orange
C	N/A	Red	Blue	Yellow
Neutral	White	White	White	Gray**
Equipment Ground	Green	Green	Green	Green
Isolated Ground	N/A	N/A	Green/Yellow Stripe	N/A

**Except as provided in NFPA 70.

B. Conductors shall not be smaller than No. 12 AWG, except that wiring for signal and pilot control circuits and pre-manufactured whips for light fixtures may be No. 14 AWG.

2.04 METAL CLAD CABLE, TYPE MC

A. General
   1. Metal Clad Cable, Type MC (for non-patient care areas only. Do not use for life safety or critical systems.)

B. 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 the NEC. 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 NEC Table 250.122.
   6. Marking: Cable markings shall comply with the requirements on NEC ART. 310.11.

C. 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 the NEC. 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 NEC Table 250.122.
   6. Control Conductors: color coded class2/class3 twisted jacketed pairs

7. Marking: Cable markings shall comply with the requirements of NEC Art 310 .11(1).

D. 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.

2.05 METAL CLAD CABLE – HEALTH CARE FACILITY RATED TYPE MC- HCF

A. General
   1. Use allowed for normal power circuits in general patient care areas.
   2. Do not use for life safety or critical systems.

B. Metal Clad Cable – Health Care Facility Rated Type MC- HCF: (use allowed for normal power circuits in general patient care areas. Do not use for life safety or critical systems).
   1. Manufacturers:
      a. AFC Cable Systems, Inc. (MC- Stat)
      b. Encore Wire Corporation (MC- MCMP)
      c. Southwire Company (HCF – MCAP)
   2. 600V, Unjacketed and/or PVC-jacketed UL Standard 1569 for Metal-Clad cables, UL Standard 83, UL Standard 1063, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and the NEC. MC cable shall be listed for use in UL 1, 2, and 3 Hour through-Penetration Firestop Systems.
   3. Armor Assembly: Aluminum interlocked armor and full-sized solid bare aluminum grounding/bonding conductor in intimate and continuous contact with armor – recognized as equipment ground per NEC Articles 250.118 and 517.13(A).
   4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
   5. Grounding Conductor: Solid, soft-drawn copper, THHN green insulated grounding conductor sized per NEC 517.13(B) and Table 250.122.
   6. Type MC-HCF Cable shall be “Hospital Care Facility” type in accordance with NEC section 517.13 with raceway system listed as an equipment ground return path.
   7. Marking: Cable markings shall comply with the requirements of NEC Art 310 .11(1). Outer armor shall have green-color for easy identification as hospital patient care rated.

C. MC – HCF Cable (with 0-10V dimming control wiring):
   1. Manufacturers:
      a. AFC Cable Systems, Inc. (MC- HCF-PCS)
      b. Encore Wire Corporation (MC- HCF-PCS)
      c. Southwire Company (MC-HCF-PCS Duo)
   2. 600V, Unjacketed and/or PVC-jacketed UL Standard 1569 for Metal-Clad cables, UL Standard 83, UL Standard 1063, Federal Specification A-A59544, IEEE 1202 Vertical Cable Tray Flame Test and the NEC. MC cable shall be listed for use in UL 1, 2, and 3 Hour through-Penetration Firestop Systems.

3. Armor Assembly: Aluminum interlocked armor and full-sized solid bare aluminum grounding/bonding conductor in intimate and continuous contact with armor – recognized as equipment ground per NEC Articles 250.118 and 517.13(A).
4. Phase Conductors: Solid soft-drawn copper, THHN-insulated single conductors, color code: ICEA Method 1.
5. Control Conductors: color coded class2/class3 twisted jacketed pairs
6. Grounding Conductor: Solid, soft-drawn copper, THHN green insulated grounding conductor sized per NEC 517.13(B) and Table 250.122.
7. Type MC-HCF Cable shall be “Hospital Care Facility” type in accordance with NEC section 517.13 with raceway system listed as an equipment ground return path.
8. Marking: Cable markings shall comply with the requirements of NEC Art 310 .11(1). Outer armor shall have green-color for easy identification as hospital patient care rated.

D. 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); 300 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.

2.06 FLEXIBLE CORDS

A. 600V, multi-conductor (2, 3, or 4 as indicated on the Drawings), oil-resistant black or yellow jacket, extra-hard-usage; Type SEO, SO, or STO for indoor dry and damp locations; SEOW, SOW, or STOW for damp, wet, and outdoor locations; or as required by the manufacturer of the equipment to which the cords are connected.

B. 300V, multi-conductor (2, 3, or 4 as indicated on the Drawings), oil-resistant black or yellow jacket, hard-usage; Type SJEO, SJO, or SJTO for indoor dry locations; SJEOW, SJOW, or SJTOW for damp, wet, and outdoor locations; or as required by the manufacturer of the equipment to which the cords are connected.

2.07 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.

2.08 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-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-hole pad.

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. Connectors for stranded conductors No. 10 AWG and smaller: Tinned copper, insulated-sleeve, compression type, UL-listed, with wire insulation grip.
   1. Terminations:
      a. Flanged fork-tongue type
      b. Ring-tongue type

F. Connectors and terminations for aluminum conductors and cables No. 1 and larger: UL 486B listed and marked AL7CU for 75 deg C rated conductors and AL9CU for 90 deg C rated conductors.

PART 3 - EXECUTION

3.01 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).

3.02 INSTALLATION

A. General
   1. Install in accordance with manufacturer's instructions.
   2. 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.

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. Wiring at Outlets: Install conductors at each outlet with at least 12 inches of slack.
7. Common or Shared Neutrals are not allowed unless shown on the plans or specifically noted to be allowed.
8. Multi-wire branch circuits (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 example
9. 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:
    1) Maximum of eight conductors in a single raceway. Minimum raceway size: ¾-inch. Do not install any other type of circuit in this raceway.
    2) Only 15A and 20A branch circuit homeruns may be combined into one raceway.
    a. Emergency Power Circuits – includes all circuits covered under Articles 700, 701 and 702.
    b. Healthcare Critical branch circuits as defined in Article 517.
    c. GFCI-protected circuits.

    3) Do not use multi-conductor circuits, with a shared neutral, for any GFCI circuit breaker or receptacle circuit.
    4) Do not use multi-conductor or MC cables.
    5) Do not share neutrals between separate circuits.
10. 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.
11. 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.
12. 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.
        4)
        5) Feeders and branch circuits: UF or USE.

B. Metal Clad Type MC and/or Metal Clad Health Care Facility type MC-HFC Cable:
1. Securing and Supporting:
    a. Support per Art 330 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 and/or MC-HCF 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 the NEC.
3. MC and/or MC-HCF 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 and/or HCF
      1) In locations not permitted by the NEC.
      2) When specifically not allowed by the local AHJ or Owner.
      3) Homeruns to panelboards. Note: where metal clad cable is utilized for receptacle, lighting, and/or miscellaneous load branch circuiting, the originating point of the homerun shall be at the first (most upstream) load in the circuit or at a junction box located in the accessible ceiling space immediately above the first (most upstream) load. Reference definitions in this section for definition on “Homerun”.
      4) Where exposed to view.
      5) Where subject to physical damage.
      6) Corrosive or Hazardous locations.
      7) Wet locations.
      8) Emergency systems (life safety and critical branches) of Health Care facilities accept as allowed by Art 517.30(C)(3).
      9) Emergency circuits covered by NFPA Art 700 Emergency Systems
   b. PVC Jacketed MC and/or HCF
      1) In locations not permitted by the NEC.
      2) When specifically not allowed by the local AHJ or Owner.
      3) Homeruns to panelboards. Note: where metal clad cable is utilized for receptacle, lighting, and/or miscellaneous load branch circuiting, the originating point of the homerun shall be at the first (most upstream) load in the circuit or at a junction box located in the accessible ceiling space immediately above the first (most upstream) load. Reference definitions in this section for definition on “Homerun”.
      4) Where subject to physical damage.
      5) Emergency circuits covered by NFPA Art 700 Emergency Systems
4. Type MC- HCF cable shall have an outer metal armor or sheath in accordance with NEC Art 517.13(A). This requirement applies to MC- HCF cable installations for non-emergency (non-life safety & non-critical) circuits in General Patient Areas i.e. Patient bedrooms, examining rooms, treatment rooms, clinics, and similar areas within health care facilities including but not limited to, hospitals, nursing homes, limited care facilities, clinics, medical and dental offices, and ambulatory care centers, whether permanent or movable.
   a. This further applies to any area where it is intended that the patient will come in contact with ordinary appliances such as a nurse call system, electric instrument, cord

connected equipment, electric beds, examining lamps, telephones, and entertainment devices.

b. Type MC- HCF Health Care Facility cable is permitted for use in general patient care areas of health care facilities. The use of standard/non-health care facility type MC or AC cable is not permitted in patient care areas.

c. The HCF length for power circuits shall be limited to 30 feet from the junction box to the wiring device located in the wall. If the circuit continues outside the wall, the circuit shall immediately transition to conduit.

d. The HCF length for lighting circuits shall be limited to 30 feet from the junction box to the first fixture and from that point only those fixtures above the enclosed space/room shall be served by this HCF circuit.

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 specified, and permitted by local codes, only cable for communication or fire alarm systems and low voltage control wiring may be installed without raceways.
3. 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 oxide inhibitor in each splice and tap conductor for aluminum conductors.
5. 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.
6. 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
7. Do not use terminals on wiring devices to feed through to the next device.

3.03 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 No. 1/0 AWG and larger in vaults, pull and junction boxes identify 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 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."

3.04 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 26 05 19

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 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 Conductors
2. Connector Products
3. Miscellaneous Grounding Materials and Products

1.02 DEFINITIONS

A. The following apply to this and other Sections of these Specifications:

1. EMT: Electrical metallic tubing.
2. ENT: Electrical nonmetallic tubing.
3. FMC: Flexible metal conduit.
4. IMC: Intermediate metal conduit.
5. LFMC: Liquidtight flexible metal conduit.
6. LFNC: Liquidtight flexible nonmetallic conduit.
7. RMC: Rigid Metal Conduit
8. GRS: Galvanized Rigid Steel Conduit
9. RAC: Rigid Aluminum Conduit
10. RNC: Rigid nonmetallic conduit.
11. PSF: Pounds per Square Foot

1.03 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. Mechanical and compression connectors, and exothermic connectors.

B. Qualification Data: For a qualified testing and inspecting agency engaged by 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 exterior buried electrodes and all buried ground rings. Indicate dimensions from fixed structural elements.

1.04 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 (current version), "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.
   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.

D. 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.
   3. Comply with UL 467.

E. Comply with NFPA 70.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

B. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference.

2.02 GROUNDING CONDUCTORS AND CONNECTORS:

A. Manufacturers:
   1. Apache Grounding/Erico Inc.
   2. Boggs, Inc.
   3. Chance/Hubbell.
   4. Copperweld Corp.
   5. Dossert Corp.
   6. Erico Inc.; Electrical Products Group.
   7. FCI/Burndy Electrical.
   8. Galvan Industries, Inc.
   9. Harger Lightning Protection, Inc.
   10. Hastings Fiber Glass Products, Inc.
   11. Heary Brothers Lightning Protection Co.
   12. Ideal Industries, Inc.
   13. ILSCO.
   14. Kearney/Cooper Power Systems.
   15. Korns: C. C. Korns Co.; Division of Robroy Industries.
   16. Lightning Master Corp.
   17. Lyncole XIT Grounding.
   18. O-Z/Gedney Co.; a business of the EGS Electrical Group.
   19. Panduit, Inc
   20. Raco, Inc.; Division of Hubbell.
   21. Robbins Lightning, Inc.

22. Salisbury: W. H. Salisbury & Co.
23. Superior Grounding Systems, Inc.
24. Thomas & Betts, Electrical.

2.03 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables"

B. Material:
   1. Copper.

C. Equipment Grounding Conductors: Insulated and identified as indicated in Part 3 of this section.

D. Grounding Electrode Conductors: Bare, stranded, unless otherwise indicated.

E. Bare Copper Conductors:
   1. Solid Conductors: Comply with Conductors: ASTM B 8.
   2. Tinned Conductors: Comply with ASTM B 33.

F. 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.

G. Ground Conductor and Conductor Protector for Wood Poles: As follows:
   1. No. 4 AWG minimum, soft-drawn copper conductor.
   2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir, or cypress or cedar.

2.04 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
   1. 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:
      a. Company symbol and/or logo.
      b. Catalog number.
      c. Conductors accommodated.
      d. Installation die index number or die catalog number is required.
      e. Underwriters Laboratories “Listing Mark:”.
      f. The words “Suitable for Direct Burial” or, where space is limited, “Direct Burial” or “Burial” per UL Standard ANSI/UL467 (latest revision).
   2. Cast connectors: copper base alloy according to ASTM B 30 (latest revision).

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

PART 3 - EXECUTION

3.01 EXAMINATION

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.

3.02 INSTALLATION

A. GENERAL

1. Provide all materials, labor and equipment for an electrical grounding system in accordance with applicable portions of the NEC and NECA. Coordinate electrical work as necessary to interface installation of electrical grounding systems with other work.
2. 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.
3. 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

1. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
2. In branch circuit and feeder raceways, use insulated equipment grounding conductors.
3. Equipment Grounding Conductors
   a. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
   b. Install equipment grounding conductors in all feeders and branch circuits.
   c. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NFPA 70:
      1) Feeders and branch circuits.
      2) Lighting circuits.
      3) Receptacle circuits.
      4) Single-phase motor and appliance branch circuits.
      5) Three-phase motor and appliance branch circuits.
      6) Flexible raceway runs.
      7) Armored and metal-clad cable runs.
      8) Feeders and branch circuits installed in non-metallic raceways.
4. 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.
5. 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.

C. CONNECTIONS

1. 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.

a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
b. Make connections with clean, bare metal at points of contact.
c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
d. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

2. 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:
   a. Connecting conductors together.
   b. Connecting conductors to building steel.
   c. Connecting conductors to plates.
3. 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.
4. Mechanical Pressure Fittings: Use bolted mechanical (removable) pressure-type clamps for the following:
   a. Connecting conductors to pipes.
5. 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.
6. 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.
7. 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.
8. 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.

3.03 IDENTIFICATION

A. Provide identification as specified in Division 26 “Low-Voltage Electrical Power Conductors and Cables” and “Identification for Electrical Systems”

3.04 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 Values:

a. Equipment Rated 500 kVA and Less: 10 ohms.
b. Equipment Rated 500 to 1000 kVA: 5 ohms.
c. Equipment Rated More Than 1000 kVA: 3 ohms.

3. 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.
4. Minimum system neutral–to-ground insulation resistance: one megohm.
5. 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.

END OF SECTION 26 05 26

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.02 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.03 ADMINISTRATIVE RQUIREMENTS

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.04 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.

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.

1.05 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Nonmetallic slotted channel systems. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.06 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. ERICO International Corporation.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut; Tyco International, Ltd.
    g. Wesanco, Inc.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. 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.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. Fabco Plastics Wholesale Limited.
    d. Seasafe, Inc.
2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and\or Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

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

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1) Hilti Inc.
   2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
   3) MKT Fastening, LLC.
   4) Simpson Strong-Tie Co., Inc.; MasterSet Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 GENERAL

A. J-hooks shall be used for communication and other low voltage wiring not in conduit.

3.02 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

3.03 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway:
   1. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
   2. Space supports for EMT, IMC, and RMC as required by NFPA 70.
   3. Spacing supports for EMT, IMC, and RMC shall be as scheduled in NECA 1, where its Table 1 lists maximum spacing less than stated in NFPA 70

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with:

a. Two-bolt conduit clamps

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.04 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel:
   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
   c. Spring-tension clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.05 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

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

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.06 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.

3.07 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.

END OF SECTION 26 05 29

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL REQUREMENTS

1.01 SECTION INCLUDES

A. This Section includes:

1. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.02 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

1.03 SUBMITTALS

A. General: Submit the following in accordance with Division 01 and Division 26 Section “General Electrical Requirements”.

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 interior raceways three inches and larger. Indicate dimensions from fixed structural elements.

C. 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.

1.04 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

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

B. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference.

2.02 CONDUITS, SURFACE MOUNTED RACEWAYS AND ACCESSORIES

A. Metal Conduit and Tubing
   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. Western Tube and Conduit Corporation
      k. 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.
      a. Fittings: Set-screw or compression type.
   5. FMC: Aluminum or Zinc-coated steel: UL 1.
   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. 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. Prime Conduit (formerly Carlon)
      m. RACO; Division of Hubbell, Inc.
      n. Spiralduct, Inc./AFC Cable Systems, Inc.
      o. Superflex Ltd.

p. Thomas & Betts Corporation.

C. Metal Wireways

1. Manufacturers:
   a. Cooper B-Line
   b. EPI-Electrical Enclosures
   c. Hoffman.
   d. 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 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. Finish: Manufacturer's standard phosphate pre-treatment and baked enamel finish.

D. Surface Metal Raceways

1. Manufacturers:
   a. Wiremold/Legrand.
   b. Mono-Systems, Inc.
   c. Panduit Corp
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.

2.03 BOXES, ENCLOSURES AND CABINETS

A. General

1. Manufacturers:
   a. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
   b. Emerson/General Signal; Appleton Electric Company.
   c. Erickson Electrical Equipment Co.
   d. Hoffman.
   e. Hubbell, Inc.
   f. Killark Electric Manufacturing Co.
   g. O-Z/Gedney; Unit of General Signal.
   h. RACO; Division of Hubbell, Inc.
   i. Robroy Industries, Inc.; Enclosure Division.
   j. Scott Fetzer Co.; Adalet-PLM Division.
   k. Spring City Electrical Manufacturing Co.
   l. Thomas & Betts Corporation.
   m. Walker Systems, Inc.; Wiremold Company (The).
   n. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary

B. Outlet Boxes

1. Sheet Metal Outlet and Device Boxes: NEMA OS 1; UL514A.
2. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.

3. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified in the following paragraphs. Manufacturers and model numbers listed are used only to represent the characteristics required and are not intended to restrict the use of other Manufacturers listed above and models that meet the specified criteria.
    a. Concealed and exposed boxes for lighting:
        1) Appleton 40-3/4.
        2) RACO 160 series.
        3) Steel City 54170 series.
    b. Boxes for flush switches, receptacles, or other general devices:
        1) Appleton 4SVB series; 8400 series cover.
        2) RACO 198 series; 770 series cover.
        3) Steel City CWV series; 52-C-00 series cover.
    c. Boxes for flush switches, receptacles, or other general devices installed in masonry construction:
        1) Appleton MI-250 series or MI-350 series.
        2) RACO 690 series or 960 series.
        3) Steel City GW series.
    d. Boxes for telephone, data, telecommunications and audio-video outlets, refer to:
        1) Division 26 Section “Common Work Results for Communications”

C. Junction and Pull Boxes
    1. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
    2. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast iron or aluminum with gasketed cover.

2.04 FACTORY FINISHES

A. Finish: For metal wireway and surface raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled metal wireway and surface raceways, enclosures, and cabinets before shipping.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General
    1. Install in accordance with manufacturer’s instructions

B. RACEWAYS
    1. General
        a. 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.
        b. 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).
            1) 1/2 inch conduit shall contain maximum (5) #12AWG conductors or (3) #10AWG conductors.
            2) 3/8 inch flexible conduit may be used for light fixture whips.

c. Provide all raceways, fittings, supports, and miscellaneous hardware required for a complete electrical system as described by the Drawings and Specifications.

d. 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.

e. Install grounding bushings on all conduit terminations and bond to the enclosure, equipment grounding conductor, and electrical system ground.

f. 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.

g. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.

h. 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.

i. 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.

j. Install raceways:

    1) To meet the requirements of the structure and the requirements of all other Work on the Project.

    2) To clear all openings, depressions, ducts, pipes, reinforcing steel, and so on.

    3) 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.

    4) Parallel or perpendicular to building lines or column lines.

    5) When concealed, with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

k. 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.

l. Provide support spacing in accordance with NFPA 70 requirements, and at a minimum in accordance with NEMA standards. Support by the following methods:

    1) Attach single raceway directly to structural steel with beam clamps.

    2) 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.

    3) Attach groups of raceway to structural steel with slotted support system attached with beam clamps. Attach raceway to slotted channel with approved raceway clamps.

    4) 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.

    5) 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.

6) 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.

7) Support conductors in vertical raceway in accordance with NFPA 70 requirements.

8) Cross-brace suspended raceway to prevent lateral movement during seismic activity.

9) Use pre-fabricated non-metallic spacers for parallel runs of underground or under-slab conduits, either direct buried or encased in concrete.

m. 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.

n. 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.

o. Align and install raceway terminations true and plumb.

p. Complete raceway installation before starting conductor installation.

q. 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.

r. Install approved expansion/deflection fittings where raceways pass through or over building expansion joints.

s. 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:

1) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces or from building exterior to building interior.

2) Where otherwise required by NFPA 70.

t. 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.

2. RMC

a. Use GRS or IMC in the following areas:

1) Where indicated.

2) For Emergency Feeders.

3) 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.

b. Use RAC in the following areas:

1) Indoors above grade.

2) Interior wet or damp locations.

c. Do not use RAC:

1) Below grade.

2) Imbedded in concrete or other areas corrosive to RAC.

3. EMT

a. Use EMT in the following areas:

1) Where indicated.

2) Interior concealed locations for:

a) Branch circuits.

b) Feeders.

c) Emergency branch circuits.

d) Low-voltage control, security, and fire alarm circuits

3) Exposed where not subject to physical damage

a) Mechanical rooms

b. Do not use EMT:

1) Below grade.

2) In exterior applications when exposed.

4. FMC and LFMC

a. Use FMC or LFMC:

1) For the final 24 inches of raceway to all motors, transformers, and other equipment subject to vibration or movement.

2) 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.

3) Use FMC only in dry locations

b. Do not use FMC or LFMC:

1) For branch circuits, homeruns or feeders.

2) In lengths exceeding 6 feet.

5. 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.

C. RACEWAY FITTINGS:

1. Compatible with raceways and suitable for use and location.

2. RMC and IMC: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3. Join raceways with fittings designed and approved for that purpose and make joints tight.

4. Use insulating bushings to protect conductors at raceway terminations:

a. 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.

b. 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.

D. Smoke Evacuation

1. Life Safety feeders shall be installed in fire rated enclosures or shall be constructed as a rated assembly per NEC700 and IBC 403.
2. Life Safety feeders shall not be routed in the same enclosures as other feeder types except as permitted by NEC 700.
3. Life Safety loads shall be as defined by NEC 700 and IBC 403 including but not limited to the following:
    a. Egress Lighting

E. BOXES
1. General
    a. Verify locations of device boxes prior to rough in.
    b. Set boxes at elevations to accommodate mounting heights as specified or indicated on the Drawings.
    c. Electrical boxes are shown on Drawings in approximate locations unless dimensioned. Adjust box locations to accommodate intended purpose.
    d. Install boxes to preserve fire ratings of walls, floors, and ceilings.
    e. Install flush wall-mounted boxes without damaging wall insulation or reducing its effectiveness.
    f. Support boxes independently of raceway.
    g. Clean the interior of boxes to remove dust, debris, and other material. Clean exposed surfaces and restore finish.
    h. Adjust flush-mounted boxes to make front edges flush with finished wall material.
    i. 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.
    j. 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.
2. NEMA Enclosure ratings:
    a. NEMA 250, type 1
        1) Provide at interior and dry locations
3. Outlet Boxes
    a. Install all electrical devices, such as plug receptacles, lamp receptacles, light switches, and light fixtures in or on outlet boxes.
    b. 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.
    c. 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.
    d. Install extension and plaster rings as required by NFPA 70.
    e. 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.
    f. Do not exceed allowable fill per NFPA 70.

g. Where multiple devices are shown grouped together, gang mount with a common cover plate.

4. Junction and Pull Boxes
   a. Install junction and pull boxes above accessible ceilings and in unfinished areas.
   b. Provide boxes set flush in painted walls or ceilings with primer coated cover.
   c. Where junction and pull boxes are installed above an inaccessible ceiling, locate so as to be easily accessible from a ceiling access panel.

3.02 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
      b. Snap-Around Labels
      c. Snap-Around, Color-Coding Bands
      d. Self-Adhesive Vinyl Tape
   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
   2. Snap around label
   3. Self-adhesive vinyl tape applied in bands.

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.
2. The junction box where a homerun ends and the circuit is distributed shall be marked. Junction boxes shall be marked approximately every 100 feet along homerun path to panel.

END OF SECTION 26 05 33

SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL REQUIREMENTS

1.01 SUMMARY

A. This Section includes:
   1. Raceways, fittings, boxes for underground electrical systems
   2. Pull boxes
   3. Direct buried electrical ducts
   4. Concrete-encased electrical ducts

1.02 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

1.03 COORDINATION

A. Coordinate layout and installation of ducts, handholes, and pull 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 pull 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 from handholes, and as approved by the Contract Administrator.

1.04 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, pull boxes, and warning tape.

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.

1.05 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 pull boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
   1. Tests of materials shall be performed by an independent testing agency.

2. Strength tests of complete boxes and covers shall be by either an independent testing agency or 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.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

C. Where a list is provided, manufacturers are listed alphabetically and not in accordance with any ranking or preference.

2.02 RACEWAYS AND FITTINGS

A. Metal Conduit and Tubing

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

B. Nonmetallic Raceway and Tubing

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. 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.

D. Materials: Comply with ASTM C858 and with Division 03 Section “Cast-In-Place Concrete.”

PART 3 - EXECUTION

3.01 EXAMINATION

A. Receive and inspect precast or premanufactured equipment.
B. Examine components before installation. Reject components that are damaged.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install all components per manufacturer’s recommendations.

3.03 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600volts and Less: RNC, NEMA Type EPC-40 PVC, in concrete-encased duct bank, unless otherwise indicated.
B. Ducts for Electrical Feeders 600 volts and Less: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank, unless otherwise indicated.
C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40 PVC, direct-buried duct bank, unless otherwise indicated.
D. Underground Ducts Crossing Paved Paths: RNC, NEMA Type EPC-40 PVC, encased in reinforced concrete.

3.04 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 top soiling, 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.”

3.05 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down away from buildings and equipment. Slope ducts from a high point in runs between two points to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48-inches, 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. Building Wall Penetrations: Make a transition from underground duct to PVC coated 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."

E. 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.

F. Pulling Cord: Install 100-lbf test nylon cord in ducts, including spares.

G. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet 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 handholes, pull boxes or 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 without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3-inches between ducts and exterior envelope wall, 2-inches between ducts for like services, and 4-inches between power and signal ducts.
7. Depth: 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 PVC coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3-inches 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.

H. Direct-Buried Duct Banks:
1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet 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 PVC coated rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3-inches 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 and duct banks placing them 24-inches o.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.

3.06 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section “Grounding and Bonding for Electrical Systems.”

3.07 INSTALLATION ACCEPTANCE

A. Prior to final acceptance of the duct bank and associated structures, pull an aluminum or 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.

B. Test duct bank, handhole and pull box grounding to ensure electrical continuity of grounding and bonding connections.

C. 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.

D. Clean internal surfaces of handholes and pull boxes and remove foreign materials.

END OF SECTION 26 05 43

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes the following:
   1. Nameplates
   2. Identification for raceways and metal-clad cable.
   3. Identification for conductors, communication, and control cable.
   4. Labels for junction boxes and pull boxes.
   5. Labels for wiring devices.
   6. Underground-line warning tape.
   7. Warning labels and signs.
   8. Instruction signs.
   9. Equipment identification labels.
   10. Miscellaneous identification products.

1.02 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. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

D. Coordinate installation of identifying devices with location of access panels and doors.

E. Install identifying devices before installing acoustical ceilings and similar concealment.

1.03 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 are acceptable to authorities having jurisdiction.
   2. Marked for intended use.

B. Comply with ANSI A13.1 and ANSI C2.

C. Comply with NFPA 70.

D. Comply with 29 CFR 1910.145.

PART 2 - PRODUCTS AND MATERIALS

2.01 GENERAL

A. Location, text, and method of identification to be used is noted in individual sections. Refer to related sections for additional identification requirements.

2.02 NAMEPLATES

A. Engraved, Laminated Acrylic or Melamine Label, adhesive backed. 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 2 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. Confirm nameplate colors with building standards.

1. Normal systems - white letters on a black background.
2. Emergency systems - white letters on a red background

2.03 LABELS FOR RACEWAYS AND METAL-CLAD CABLE

A. 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.

B. 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.

C. 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.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.04 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.

2.05 LABELS FOR WIRING DEVICES AND LIGHTING CONTROL 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.

B. Engraved, Laminated Acrylic or Melamine Label: adhesive backed. Minimum letter height shall be 3/16 inch (4.76 mm).

1. Normal systems - white letters on a black background.
2. Emergency systems - white letters on a red background

C. Engraved cover plates: Provide with white letters. White or ivory cover plates shall have black letters.

2.06 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.

2.07 TAGS

A. Write-On Tags: Polyester tag, 0.015 inch (0.38 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.

2.08 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
   1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip or core.
   4. Printed legend shall indicate type of underground line.

2.09 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 printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 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. 1/4-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. 3.5 in. x 5 in., unless otherwise noted by Owner, thermal transfer type label of high adhesion polyester for each work location analyzed.

B. 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.

C. The label shall include the following information, at a minimum:
   1. Location designation
   2. Nominal voltage
   3. Available Fault Current
   4. Flash protection boundary
   5. Hazard risk category
   6. Incident energy
   7. Working distance
   8. Engineering report number, revision number and issue date.

D. Labels shall be machine printed, with no field markings.

2.11 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes. Unless indicated otherwise, provide with minimum 3/8-inch- (10-mm-) high letters.
   1. Punched or drilled for mechanical fasteners.
   2. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
   3. Normal systems: Engraved legend with white letters on black face.
   4. Essential Systems: Engraved legend with white letters on red face.

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.

2.13 PAINTED IDENTIFICATION

A. Paint materials and application requirements are specified in Division 09 painting Sections.
   1. 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.
   2. 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.
   3. 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.
   4. 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.
   5. 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.

2.14 FASTENERS FOR NAMEPLATES, LABELS AND SIGNS

A. Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat lock washers unless otherwise noted.

PART 3 - EXECUTION

3.01 PREPERATION

A. Verify identity of each item before installing identification products.

B. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

C. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. For surfaces that require finish work, apply identification devices after completing finish work.

C. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

D. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

E. 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.

F. 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

END OF SECTION 26 05 53

SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies, and the setting of these devices.
   1. Also include coordination of series-rated devices where series rating is specified in other sections and where indicated on Drawings.
   2. The AIC ratings indicated on the Drawings are preliminary and will be finalized based on the results of the fault current study. Device ratings for furnished equipment shall be as required by the results of the fault current study at no additional cost.

B. Study must be completed and submitted for review prior to final order, assembly or shipping of the electrical distribution system components. 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.

1.02 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Studies:
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Coordination-study report.
   3. Equipment evaluation report.
   4. Arc-Flash Hazard Analysis.
   5. Setting report.

E. Preliminary Studies
   1. Submit a Fault-Current Study and Overcurrent Protective Device Setting Study to the Engineer prior to receiving final approval of the shop drawings and/or prior to release of equipment drawings for manufacturing. The preliminary studies shall provide sufficient data to ensure that the selection of equipment will have adequate ratings and the protective device trip characteristics will be satisfactory.

F. Final Studies
   1. Perform a final Fault-Current Study, Overcurrent Protective Device Setting Study and Arc Flash Hazard Analysis at the end of the construction cycle when circuits are installed and all equipment is on site and/or installed such that complete and accurate data may be obtained.

G. Submittals for construction
   1. The single-line diagram and results of the final short-circuit, protective device coordination, and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound volumes of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) volumes of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies of the short-circuit input and output data shall be provided on CD in PDF format.

2. Provide the single-line diagram, short-circuit, coordination, and arc flash project files to the Owner in electronic format including all project files, libraries, etc. to allow the owner to update and to print additional copies, labels, etc.
3. A copy of the computer analysis software viewer program is required to accompany the electronic project files, to allow the Owner to review all aspects of the project and print arc flash labels, one line diagrams, etc.
4. The report shall include the following sections:
    a. Executive Summary,
    b. Descriptions, purpose, basis and scope of the study.
    c. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short circuit duties.
    d. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, and fuse selection.
    e. Fault current calculations including a definition of terms and guide for interpretation of the computer printout.
    f. Details of the incident energy and flash protection boundary calculations.
    g. Recommendations for system improvements, where needed.
    h. One line diagram.
    i. Equipment specific arc flash labels.

H. 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.

I. Electronic files, in an SKM-compatible format, of the time-current characteristic curves for every different overcurrent device used in the reports.

1.03 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. Coordination-Study Specialist 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 where Project is located, shall be responsible for the study. 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 242 for short-circuit currents and coordination time intervals.

E. Comply with IEEE 1584 and NFPA 70E for arc-flash hazard calculations.

PART 2 - PRODUCTS AND MATERIALS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide computer software programs 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.

2.02 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-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. Simultaneous faults.

PART 3 - EXECUTION

3.01 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. Fault current 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 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.

3.02 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 on both sides of any transfer switch, contactor or circuit breaker.

B. Components include, but are not limited to:

1. Switchgear
2. Switchboards
3. Distribution Panelboards
4. Panelboards
5. Generators

3.03 POWER SYSTEM DATA FOR STUDIES

A. 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. Circuit-breaker and fuse-current ratings and types.

b. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.

c. Cables. Indicate conduit material, sizes of conductors, conductor insulation, and length.

d. Busway ampacity and impedance.

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. Magnetic inrush current overload capabilities of transformers.

c. Ratings, types, and settings of utility company's overcurrent protective devices.

d. Time-current-characteristic curves of devices indicated to be coordinated.

e. 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.

f. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

g. Panelboards, switchboards, and interrupting ratings in amperes rms symmetrical.

3.04 FAULT-CURRENT STUDY

A. Source Impedance:

1. Utility company's fault-current contribution as indicated.

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 operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard. Estimated conductor lengths, typical generator, transformer, motor, and utility data may be used for the preliminary study.

E. Actual installed conductor lengths, test and/or nameplate data for all generators, transformers, motors 50 HP and larger, capacitors, reactors, or other equipment that may affect the study shall be used for the final study.

F. Comply with IEEE 242 recommendations for fault currents and time intervals.

G. 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.

H. Study Report:

1. Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report.

2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

3. 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.

I. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.05 COORDINATION STUDY

A. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

C. Comply with IEEE 242 recommendations for fault currents and time intervals.

D. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
    a. Inrush current when first energized.
    b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
    a. Device tag.
    b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
    c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
    d. Fuse-current rating and type.
    e. Ground-fault relay-pickup and time-delay settings.
2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve the level of selective coordination required in the contract documents or by the edition of the National Electrical Code (including any local jurisdiction amendments) the project must comply with. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information where applicable:
    a. Device tag.
    b. Voltage and current ratio for curves.
    c. Three-phase and single-phase damage points for each transformer.
    d. No damage, melting, and clearing curves for fuses.
    e. Cable damage curves.
    f. Maximum fault-current cutoff point.
    g. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    h. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands.
    i. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves. The frequent fault portion of the damage curve should not be shown unless the transformer feeds overhead lines. The shifted curve for line-to-ground faults on the secondary side shall be shown on the ground fault plot.

j. Ground fault protective devices shall be shown on separate TCC plots. The first phase overcurrent relay and any negative sequence relays on the primary side of a delta-wye transformer shall be shown.

3. Completed data sheets for setting of overcurrent protective devices.
4. For emergency, legally required standby and health care essential power systems, such systems must selectively coordinate to the values indicated below unless local amendments to the National Electrical Code require a different value.
   a. Health Care Essential Electrical Systems (NEC article 517)
      1) Equipment Branch 0.10 seconds
      2) Critical Branch 0.01 seconds
      3) Life-Safety Branch 0.01 seconds

3.06 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of 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 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.

3.07 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. Perform the analysis under worst-case arc-flash conditions for all modes of operation.

B. 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.

C. 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 scenarios evaluated and identification of the 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. Conclusions and recommendations.

D. Arc Flash Warning Labels
1. Provide required arc-flash labeling and placement of labels as described in Division 26 Section “Identification for Electrical Systems”.
2. Arc flash labels shall be provided on all serviceable equipment in accordance with NFPA 70E.

E. Arc Flash Training
1. Provide training for the Owner's qualified electrical personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours).

END OF SECTION 26 05 73

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes the following lighting control devices:
   1. Indoor occupancy sensors.
   2. Switchbox mounted occupancy sensors.

1.02 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.03 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.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Occupancy sensors
      a. Catalog cut sheets, including major and minor motion coverage patterns, time delay and sensitivity adjustability settings, load restrictions when used with electronic ballasts and performance specification items indicating compliance with this specification.
      b. Documentation showing compliance with California Energy Commission certification.

B. Shop Drawings:
   1. Light-level sensors
      a. Show installation details.
      b. Interconnection diagrams showing field-installed wiring.
   2. Occupancy sensors
      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. List of ballast types and lamp combinations compatible with occupancy sensors.
      f. 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 layout 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

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.

1.05 QUALITY ASSURANCE

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

B. Occupancy Sensors

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.

1.06 WARRANTY

A. Occupancy manufacturers shall provide a five (5) year warranty for sensors and accessories from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 INDOOR OCCUPANCY SENSORS

A. In the Lighting Control Device 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 specified occupancy sensor 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 equivalent manufacturers specified in the schedule.

B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors. Integral relay unit for line voltage sensors and a separate relay unit for low voltage sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Operation: Unless otherwise indicated, turn lights and motor or equipment loads on when covered area is occupied, and turn loads off when unoccupied; with a time delay for turning loads off, adjustable over a minimum range of 1 to 15 minutes with a maximum of 30 minutes.

3. Low Voltage Occupancy Sensors

a. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the power pack.

b. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 20-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70; different dc voltages and mA ratings may be acceptable as defined by NFPA 70 and when coordinated and compatible with connected occupancy sensors.

c. Sensors shall be capable of being combined with additional sensors to achieve adequate coverage.

4. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outlet box.

b. Power Pack: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.

c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the “on” function in case of sensor failure, concealed on unit to prevent tampering.
7. Sensor coverage pattern shall have been confirmed with Nema WD7 Guide and Robotic test method.
8. UL Listed for dry locations and complies with local codes.
9. Operating temperatures of 32 degree F through 104 degree F, and relative humidity of 0%-95%.
10. 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.
11. Sensors shall be capable of operating normally with electronic ballasts, PL lamp systems and rated motor loads.
12. Isolated relay with NO and NC contacts to interface with BMS, HVAC and or other building monitoring systems.
13. Sensors and related relays shall be compatible with the specific lighting types controlled.
14. Finish: Available in white or off-white finish.

C. PIR Type: Ceiling or wall mounted as indicated on plans; detect occupancy by sensing a combination of infrared heat and movement.

1. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
2. Detection Coverage: As indicated in Lighting Control Device Schedule on Drawings.
3. Sensor shall utilize pulse count processing and digital signature analysis to respond only to those signals caused by human motion.
4. Sensor shall provide high immunity to false triggering from RFI and EMI.
5. 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.

D. Ultrasonic Type: Ceiling mounted as indicated on plans; detect occupancy by sensing a change in pattern of reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection 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.
5. Detection Coverage: As indicated in Lighting Control Device Schedule on Drawings.

E. Dual-Technology Type: Ceiling or wall mounted as indicated on plans; detect occupancy by using a combination of PIR and ultrasonic detection methods. Particular technology or

combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: PIR Component detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and Ultrasonic component detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Different LED indicator colors for each sensing technology
4. PIR Sensor Component
    a. Shall utilize pulse count processing and digital signature analysis to respond only to those signals caused by human motion.
    b. Provide high immunity to false triggering from RFI and EMI.
    c. 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.
5. Ultrasonic Sensor Component
    a. 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.
    b. 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.
    c. Sensors shall be capable of automatically adapting to airflow conditions or filtering frequency spectrum related to air movement.
6. Detection Coverage: As indicated in Lighting Control Device Schedule on Drawings.

2.02 SWITCHBOX MOUNTED LINE VOLTAGE OCCUPANCY SENSORS

A. In the Lighting Control Device 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 specified occupancy sensor 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 equivalent manufacturers specified in the schedule.

B. General Description for Sensors: Line voltage occupancy sensor, suitable for mounting in a single gang switchbox.
    1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
    2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
    3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.
    4. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied. PIR senses motion using infrared heat detection. Dual technology sensors detect occupancy by using a combination of PIR and ultrasonic detect methods. Particular technology or combination of technologies shall be field selectable by operating controls on unit.
    5. Single-gang wall box switch, 120/277VAC, vandal-resistant lens, integral sliding blinders or pre-cut tape strips to block sensor views, protrudes no greater than 0.50 inches from wall.

6. LED indicator for visual detection of motion, audible and/or visual alerts for pending shut-off, light level sensor, 180-degree field of view, major and minor motion coverage patterns confirmed per Nema WD7 guidelines.
7. On Operation: Concealed, field-adjustable for auto-on or manual-on operation.
8. Concealed, field-adjustable, “off” time-delay selector with multiple increments from 30 seconds up to 30 minute time delay.
9. Adaptive technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false “off” switching.
10. Suitable for switching load types used, including fluorescent, incandescent, magnetic and electronic low voltage and motor load types. UL listed and labeled, zero-cross relay, no minimum load requirement, ground wire.
11. 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
12. Ambient Light-Level Override: Concealed, field-adjustable sensor from 10 to 150 FC. The switch prevents the lights from turning ON when the light level is higher than the set point of the sensor.

C. Single relay wall switch occupancy sensors: Manufacturer and sensing technology as indicated in Lighting Control Device Schedule. Single relay for controlling loads or circuits, single pushbutton for manual on/off control of loads. Set pushbutton ON operation (manual or automatic) as indicated in the Lighting Control Device Schedule.

D. Dual-relay wall switch occupancy sensors: Manufacturer and sensing technology as indicated in the Lighting Control Device Schedule. Two relays for controlling two independent loads or circuits, two push buttons for independent control of dual loads or circuits. Set first and second pushbutton ON operation (manual or automatic) as indicated in the Lighting Control Device Schedule.

E. Dual-technology wall switch occupancy sensors:
   1. 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.

2.03 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.01 INSTALLATION

A. GENERAL
   1. Install in accordance with manufacturer’s instructions.

B. SENSORS
   1. 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.

2. 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.
3. Occupancy sensors with ultrasonic or dual-technology sensing technologies shall be located not closer than 4 feet from an air supply device.
4. Arrange a pre-installation meeting with manufacturer's factory authorized field representative, at Owner's facility, to verify placement of sensors and installation criteria.
5. Install devices and auxiliary equipment in compliance with manufacturer's instructions and recommendations.
6. Install relay units where concealed from view and where accessible.
7. 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.
8. Install switchbox mounted occupancy sensors at 44 inches above finished floor (Dimension is to the BOTTOM of the outlet box unless noted otherwise).

C. CONTACTORS

1. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

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.

3.02 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Power and control wiring: Identify using marker tapes.
   a. Identify controlled circuits in lighting contactors.
   b. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
2. Components:
   a. Identify using the following method:
      1) Self-laminating Computer Printed Labels.
      2) Engraved, Laminated Acrylic or Melamine Label.
      3) Permanent Ink.
   b. Label each component with a unique designation matching control drawings.

3.03 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.

3.04 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.

3.05 TRAINING

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 Controls."

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."

END OF SECTION 26 09 23

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 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.

1.02 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.

1.03 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.

1.04 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.

1.05 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

2.01 MANUFACTURERS

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

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. Square D; Schneider Electric.

2.02 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.

2.03 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.
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 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

F. 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 housekeeping pad with vibration isolation pads. Wall mounted or suspended transformers shall have a means of isolating vibration from the support.
    2. Wall Mounting: Manufacturer's standard brackets.
    3. Suspended Mounting: See transformer mounting detail on plans.

G. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.
    1. 9 kVA and Less: 37 dBA
    2. 10 to 50 kVA: 42 dBA
    3. 51 to 150 kVA: 47 dBA
    4. 151 to 300 kVA: 52 dBA
    5. 301 to 500 kVA: 57 dBA
    6. 501 to 700 kVA: 59 dBA
    7. 701 to 1000 kVA: 61 dBA
    8. 1001 to 1500 kVA: 62 dBA

2.04 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.

2.05 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

3.01 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.

3.02 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Floor mounted transformers shall be mounted on a 3-1/2 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."

3.03 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."

3.04 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. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 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.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES:

A. Lighting and appliance branch-circuit panelboards.

1.02 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. SPD: Transient voltage surge suppressor.

1.03 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.

1.04 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. 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. Qualification Data: For qualified testing agency.

D. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: Submit final panelboard directories.

F. 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. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.05 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. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.06 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.

1.07 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.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within the following time period:
   1. Warranty Period: Five years from date of Substantial Completion.

1.01 INTERRUPTION OF EXISTING ELECTRICAL DISTRIBUTION SYSTEMS:

A. Refer to Division 26 Section “General Electrical Requirements” for procedures regarding interruption of electrical systems.

PART 2 - PRODUCTS

2.01 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. 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 891

E. Connections: Provide compression type unless otherwise indicated on Drawings, refer to schedules and one-line diagram. Connections shall comply with requirements of Division 26 section "Low-Voltage Electrical Power Conductors and Cables".

1. Feed-Through Lugs:

a. Locate at opposite end of bus from incoming lungs or main device.

2. Subfeed (Double Lugs):

a. Locate at same end of bus as incoming lugs or main device.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating – Fully Rated: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.02 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: Plug-in circuit breakers, replaceable without disturbing adjacent units.

2.03 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. 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.

3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
5. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
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: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
    f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional with field-adjustable 0.1- to 0.6-second time delay.
    g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
    h. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
    i. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
    j. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
    k. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
    l. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.04 ELECTRONIC-GRADE PANELBOARDS

A. Surge Protection Device: See Panelboard Suppressorssurge protection devices below.

2.05 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.

2.06 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

3.01 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.

3.02 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.

3.03 IDENTIFICATION

A. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. 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."

1. Exception: Do not install on flush panelboards and similar equipment in finished spaces.

D. Identify field-installed conductors, interconnecting wiring, and components; complying with Division 26 Section "Identification for Electrical Systems."

E. 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.

3.04 ADJUSTING

A. Adjust moving parts and operable component 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."

3.05 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

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.
3. Perform the following infrared scan tests and inspections and prepare reports:
    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:
        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. 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.

3.06 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes the following:
   1. Receptacles: Single, duplex, USB/duplex, and ground-fault circuit interrupters (GFCI).
   2. AC Wall Switches: Single- and double-pole, three- and four-way, maintained and momentary, pilot light and lighted toggle, and dimmer
   3. Device Wall Plates.
   4. Multi-Outlet Assemblies.

1.02 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

1.03 ADMINISTRATIVE REQUIREMENTS

A. Receptacles for Equipment Furnished by Owner or Under Other Divisions or Contracts: Match plug configurations.
B. Coordinate requirements indicated in Division 26 Section “Equipment Wiring Systems”.

1.04 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, and cover plates.
C. Field quality-control test reports.
D. Operations and Maintenance Data:
   1. Provide operating instructions for each type of dimmer.
E. Warranty: Special warranties specified in this Section.

1.05 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.

PART 2 - PRODUCTS AND MATERIALS

2.01 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.

2.02 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Receptacles and Switches:
      a. Cooper Wiring Devices.
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Mfg. Company Inc.
      d. Pass & Seymour/Legrand; Wiring Devices Div.
   2. Multioutlet Assemblies:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Wiremold Company (The).

B. In other Part 2 articles below, where lists of manufacturers and device catalog numbers are included, the following additional requirements apply to product selection:
   1. Additional Manufacturers: 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.

2.03 FINISHES

A. Color - normal power systems:
   1. Wiring devices:
      a. Match existing devices, unless otherwise indicated or required by NFPA 70
   2. Cover plates:
      a. Match existing cover plates

B. Color - emergency power systems:
   1. Wiring devices:
      a. Red
   2. Cover plates:
      a. Match existing cover plates

C. Color - Hospital grade receptacles:
   1. Wiring devices:
      a. As specified above, with a green dot on its face.
   2. Cover plates:
      a. As specified above

D. Manufacturer's model numbers listed are to establish the quality of the wiring devices. Coordinate the proper suffixes in order to provide the correct color as specified above.

2.04 CONVENIENCE RECEPTACLE:

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. Hospital Grade straight blade receptacles: NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, nylon face, side and back wired, self-grounding.

Manufacturer	Duplex	Single
Cooper	8300	8310
Hubbell	HBK8300	HBL8310
Leviton	8300	8310
Pass & Seymour	8300H	8301

C. Hospital Grade straight blade safety type, tamper-resistant receptacles: NEMA 5-20R, 125V, 20A, grounding type, UL listed and labeled, nylon face, side and back wired, self-grounding.

Manufacturer	Duplex
Cooper	TR8300
Hubbell	HBL8300SGA
Leviton	8300-SG
Pass & Seymour	TR63HW

D. USB/duplex convenience receptacles: NEMA 5-20R, 125V, 20A, tamper resistant, 3-wire, grounding type, UL listed and labeled, smooth nylon face, side and back wired, self-grounding; with integral USB charger having two ports, USB 2.0 compatible, 5VDC, 3A output (min).

Manufacturer	Single
Cooper	TR7756
Hubbell	USB20X2
Leviton	T5832
Pass & Seymour	TR5362USB

2.05 GFCI RECEPTACLES

A. Ground fault circuit interrupter type receptacles: Specification Grade or Hospital 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 downstream on the same circuit.

Manufacturer	Specification Grade	Hospital Grade
Cooper	VGF2	VGFH20
Hubbell	GF20LA	GFR8300HLA
Leviton	T7899-H	6898-HG
Pass & Seymour	2095	2095HG

B. Ground fault circuit interrupter type weather-resistant receptacles: Hospital 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 downstream on the same circuit.

Manufacturer	Hospital Grade
Cooper	N/A
Hubbell	GFR8300HTR
Leviton	N/A

Pass & Seymour	N/A

2.06 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: Commercial Specification grade, rated for 120/277V, 20A, back and side wired, and UL listed and labeled.

Manufacturer	1 Pole	2 Pole	3 Way	4 Way
Cooper	CSB120	CSB220	CSB320	CSB420
Hubbell	DS120	DS220	DS230	DS330
Leviton	CSB1-20	CSB2-20	CSB3-20	CSB4-20
Pass & Seymour	CS20AC1	--	CS20AC3	--

2.07 WALL BOX DIMMERS

A. Wall box dimmers: UL listed and labeled, with Radio Frequency Interference (RFI) filters to avoid interference with electronic equipment.
   1. Type as indicated on the Drawings.
   2. Wattage as indicated on the Drawings

B. Dimmer shall be suitable for dimmed load type of connected light fixture, including incandescent, magnetic low voltage, electronic low voltage, fluorescent 2-wire, fluorescent 3-wire and fluorescent 4-wire. Load types shall be as indicated on Drawings and confirmed per load type for connected luminaire as indicated in Light Fixture Schedule and approved light fixture and dimmer shop drawings.

2.08 DUAL VOLTAGE SWITCH RELAY

A. A normally-open, electrically-held relay that allows a single-pole switch to control loads operating at two different voltages (e.g., 120V and 277V); listed to UL Standard 916; installed in a 2-gang outlet box, with a voltage-separating barrier and plaster ring.

Manufacturer	Model Number
Lighting Controls and Design	GR 2001 DV – X

2.09 COVER PLATES

A. 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:
      a. Smooth nylon cover plates in finished areas.
      b. Stamped steel for exposed areas.
   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.
5. Refer to “Identification” below.

2.10 MULTI-OUTLET ASSEMBLIES

A. Surface type "plug-in" strips: 3-wire, single circuit with single grounding type, 15A, 125V receptacles, pre-wired on 18-inch centers. Provide all fittings, devices, end closures, elbows, boxes and conduit entrance fittings as required for a complete installation.

Manufacturer	Extruded Aluminum	Steel	Polycarbonate
Hubbell	HBL ALU20 Series	HBL 20GB Series	Polytrak Series
Wiremold	--	V-2000 Series	--

PART 3 - EXECUTION

3.01 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 other special type receptacles where indicated on the Drawings.

3.02 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.

3.03 PREPARATION

A. If required, provide extension rings to bring outlet boxes flush with finished surface.

B. Clean debris from in and around outlet boxes.

3.04 INSTALLATION

A. 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.

B. 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.

C. 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.

D. 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.

E. Unless dimensioned otherwise, install wiring devices a minimum of 24 inches from the closest edge of any sink.

F. Install switches with OFF position down.

G. Install wall dimmers to achieve full rating specified and indicated after de-rating for ganging as instructed by manufacturer.

H. Where dimmer switches are shown adjacent to standard switches, install both in separate back boxes with adequate space between so that neither cover plate requires cutting. Dimmers shall not require de-rating. Do not remove fins.

I. Provide a separate grounded conductor (neutral) for each circuit controlled by a dimmer. Do not share neutral conductor on load side of dimmers.

J. Install cover plates on all switches, receptacles, and blank outlets.

K. Locate wiring devices so that the cover plate does not have to be cut to be installed.

L. Where devices are shown near wall openings, coordinate location if corner guards are to be installed so that cover plates do not require cutting.

M. Install cover plates after the wall has been finished (painted, wall paper, etc).

N. 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.

O. Provide Hospital Grade receptacles throughout the facility unless otherwise noted.

P. Provide safety-type, tamper-resistant receptacles in all pediatric areas accessible to pediatric patients.

3.05 MOUNTING HEIGHTS

A. Coordinate locations of outlet boxes provided under Division 26 Section “Common Work Results for Electrical”.

B. Unless otherwise noted, 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: mount vertically.
    d. Weatherproof exterior receptacles: mount vertically.
    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 (unless otherwise indicated on the Drawings):
    a. 6 inches above counter top
4. Telephone/Data Outlet Boxes:
    a. General: Match mounting height of adjacent wiring device listed above.

3.06 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems", labels for wiring devices.

1. Unless indicated otherwise below, use the following method for all identification labels required in this section:
    a. Engraved cover plates.
    b. Engraved, Laminated Acrylic or Melamine Label.
2. Receptacles:
    a. All receptacles in critical patient care locations shall be labelled using the following method:
        1) Engraved, Laminated Acrylic or Melamine Label.
    b. In Public areas: Use permanent ink inside outlet boxes.
    c. Identify panelboard and circuit number from which served.
    d. Identify all receptacles fed downstream of GFCI protected receptacles as “GFCI PROTECTED”.
3. Switches:
    a. Use permanent ink inside back boxes.
    b. Identify panelboard and circuit number from which served.
    c. Refer to drawings for any additional labelling requirements.
4. Multi-Outlet Assemblies:
    a. Identify panel and branch circuit.

3.07 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.

3.08 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.09 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION 26 27 26

SECTION 26 28 13
FUSES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Section Includes:
   1. Cartridge fuses rated 600-V ac and less for use in:
      a. Enclosed switches
   2. Plug fuses rated 125-V ac and less for use in plug-fuse-type:
      a. Enclosed switches

1.02 ADMINISTRATIVE REQUIREMENTS

A. Coordinate fuse ratings with equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.03 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. Submit on translucent log-log graph paper if available.
   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”.

1.04 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 248-11 for plug fuses.

1.05 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.

1.06 EXTRA MATERIALS

A. Furnish extra materials that match products installed. Deliver to Owner packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussmann, Inc.
   2. Edison Fuse, Inc.
   3. Mersen Electrical Power
   4. Littelfuse, Inc.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.01 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.

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Feeders:
      a. 600A or less:
         1) Class RK1, time delay
         2) Class RK1, fast acting
         3) Class J, fast acting
         4) Class J, time delay
   2. Motor Branch Circuits:
      a. Class RK1 time delay
      b. Class RK5, time delay
   3. Other Branch Circuits:

a. Class RK1, time delay
b. Class RK5, time delay
c. Class J, fast acting
d. Class J, time delay

3.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuse holders and sockets. Ensure that adapters are irremovable once installed.

3.04 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 26 28 13

SECTION 26 43 13
SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 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.

1.02 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 Third 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 1: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device. Type 1 devices are required for Master Certification of Lightning Protection System installations under UL 96A.
   2. 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.
   3. TYPE 3: Point-of-utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, e.g., cord-connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected. The distance (10 meters or 30 feet) is exclusive of conductors provided with or used to attach SPD's.
   4. TYPE 4: Component SPDs, including discrete components as well as component assemblies for installation on panelboards or control panels.

1.03 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.

1.04 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 ANSI/ UL 1449 Third Edition.

F. Comply with NFPA 70.

G. The SPD shall be compliant with the restrictions of the Hazardous Substances (RoHS) Directive 2002/95/EC.

1.05 PROJECT CONDITIONS

A. 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.

1.06 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.

1.07 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.01 PANELBOARD SUPPRESSORS INTERNALLY MOUNTED IN PANELBOARDS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. Square D; a brand of Schneider Electric.

B. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, wired-in, solid-state, parallel-connected, modular (with field-replaceable modules) non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second 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.
   b. Audible alarm, with silencing switch, to indicate when protection has failed.
   c. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
2. Accessories:
   a. Fuses rated at 200-kA interrupting capacity.
   b. Fabrication using bolted compression lugs for internal wiring.
   c. Integral disconnect switch.
   d. Redundant suppression circuits.
   e. Redundant replaceable modules.
   f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   g. LED indicator lights for power and protection status.
   h. Audible alarm, with silencing switch, to indicate when protection has failed.
   i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   j. Six-digit, transient-event counter set to totalize transient surges.
3. Peak Single-Impulse Surge Current Rating:
   a. 160 kA per mode/320 kA per phase
   b. 120 kA per mode/240 kA per phase
   c. 80 kA per mode/160 kA per phase
4. 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
5. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
6. 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

7. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits and for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

	240/120V, 1ph, 3w	240/120V, 3ph, 4w (high leg)
Line to Neutral	400	400, 800 from high leg
Line to Ground	400	400
Neutral to Ground	400	400

8. Protection modes and UL 1449 SVR for three-phase, three-wire, delta circuits shall be as follows:

	240V	480V	600V
Line to Line	1000	2000	2500
Line to Ground	800	1500	2500

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install SPD devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. 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.

3.02 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. 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.

E. SPD device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.03 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.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to maintain SPD devices.

B. Train Owner's maintenance personnel to maintain SPD devices.

END OF SECTION 26 43 13

SECTION 26 51 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

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
2. Exit signs.
3. Emergency lighting units.
4. Light fixture supports.
5. Coordination.
6. Quality assurances.
7. Specific requirements.

1.02 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.

1.03 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 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.

1.04 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 1.05 -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 Contract Administrator’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
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.
    b. For LED lamps, include also number of MacAdam ellipse steps and L70 lifetime.
9. Photometric data, in IESNA format, including LM-79 for LED luminaires, based on laboratory tests of each light fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the light fixture as applied in this Project.

a. For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by the manufacturer.

b. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.

10. Emergency ballast cut sheet: Descriptive cut sheets providing physical description of emergency ballasts for use in normal light fixtures, including, but not limited to, complete battery information, lumens, and method for testing per NFPA 101.

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 Contract Administrator 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 Contract Administrator 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 Contract Administrator with resubmitted shop drawings for only those fixtures deemed unacceptable.
4. Contractor is responsible to call to the attention of the Contract Administrator 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 Contract Administrator, 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.
11. Perimeter moldings.

G. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

H. Qualification Data: For agencies providing photometric data for light fixtures.

I. Field quality-control test reports.

J. Operation and Maintenance Data: For lighting equipment and fixtures to include in operation and maintenance manuals.

K. Warranties: Special warranties specified in this Section.

1.05 SUBSTITUTIONS

A. Refer to Division 26 Section “General Electrical Requirements”.

B. Prior to the Bid Date, substitutions will not be considered unless the Contract Administrator/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 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 only represent in the region where the specification originated, and exclude all fixtures outside their represented lines from the MLP, and sole-sourced (proprietary) light fixtures shall not be included in the MLP.

D. 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.

E. 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 Contract Administrator/Engineer.

F. 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.

G. The Contract Administrator/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).

1.06 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.

1.07 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. 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.

1.08 EXTRA MATERIALS

A. Where light fixtures are specified with tamper proof hardware, provide the Owner with three tools for each different type of hardware.

PART 2 - PRODUCTS AND MATERIALS

2.01 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.

2.02 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.
   2. For corrosive or salt water environments, manufacturer shall provide fixtures with low copper/zinc cast aluminum (AB-47100 aluminum with less than 0.6% copper – classified for corrosive areas) housings to prevent salts from “pitting” aluminum housing. Manufacturer shall provide, in addition to or in lieu of, AB-47100 aluminum, ion added or pre-anodized polyester powder cast finish for “marine grade” applications. Manufacturer shall otherwise provide all stainless steel housing in conjunction with stainless steel hardware.
   3. Recessed downlights in corrosive or salt water interior environments shall be equipped with a “natatorium” finish comprised of a zinc-chromated and phosphated process, then powder-coated on the exterior of the housing.

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. 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. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
    c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires. Indicate maximum allowed wattage.
    d. LED type, wattage, beam angle (if applicable) for LED luminaires. Indicate maximum allowed wattage.
    e. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
    f. ANSI ballast type (M98, M57, etc.) for HID luminaires.
    g. CCT and CRI for all luminaires.

2.03 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 wall box dimmer and connecting wiring are compatible.

2.04 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.

C. Self-Luminous Signs: Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for 10 years.

2.05 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Charger: Fully automatic, solid-state type with sealed transfer relay.
2. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
4. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
5. 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.

2.06 LAMPS GENERAL

A. Unless specific manufacturers and lamp types are called for in the Light Fixture Schedule, all lamps provided for this project shall be by the same manufacturer. Lamps shall be manufactured by:

1. Eiko
2. General Electric
3. Osram/Sylvania
4. Philips
5. Soraa
6. Venture

B. All lamps shall be new and shall be delivered to the project in manufacturer's original sealed package.

C. Substitutions of specific lamp manufacturer as addressed in Light Fixture Schedule shall not be allowed. Costs associated with re-lamping due to non-compliance with specification, for both labor and material costs, shall be the sole responsibility of the contractor. For those fixtures with lamp included in fixture, contractor shall coordinate with manufacturer to ensure only approved lamp(s) is (are) installed. Lamp manufacturers indicated on Light Fixture Schedule are for reference. Where required, contractor shall coordinate with Owner regarding national purchasing agreement of specific lamp manufacturers. Purchasing of lamps, whether through competitive bidding of listed manufacturers or proprietary supply, shall be at the discretion of the Owner.

D. LED Lamps and luminaires

1. 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 4000K CCT.
2. 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.
3. Unless indicated otherwise in the Light Fixture Schedule, minimum 70% maintained initial-rated lumens at average rated life of as follows:

a. LED lamps: 20,000 hours
b. LED luminaires: 50000 hours

4. ROHS compliant
5. 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 Contract Administrator or Engineer has the authority to reject other manufacturers for technical or aesthetic reasons if felt necessary or desirable.

2.07 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.

2.08 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 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.

2.09 LIGHT FIXTURE SUPPORT COMPONENTS

A. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

B. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.

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.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify conditions of equipment and installation prior to beginning work.

B. Verify that equipment is ready for connecting, wiring, and energizing.

3.02 INSTALLATION

A. 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.

B. Temporary Lighting: If it is necessary, and approved by Contract Administrator, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. 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.

D. 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 Contract Administrator to determine final suspension heights. Regardless, contractor shall not field cut pendants or order rigid stems without elevation approval from Contract Administrator. 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.

E. 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 gypsum board ceilings and metal plank type) require throats greater than ¾", modifications to manufacturer's standard ¾" throat shall be determined by Contract Administrator 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.

F. 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.

G. 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.

H. 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 Contract Administrator prior to installation. Contractor shall supply structure to support weight of fixture.

I. 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.

J. 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 undesirable, 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.

3.03 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.

3.04 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. 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 Contract Administrator prior to beginning any work.

3.05 ADJUSTING

A. Contractor shall adjust all light fixture sockets to match the lamp specified and aim all adjustable light fixtures as directed by the Contract Administrator.

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 Contract Administrator shall coordinate with contractor as to a mutually agreed upon time to complete focusing. Failure of contractor to notify Contract Administrator during substantial completion will result in failure to comply with specifications.

3.06 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.

3.07 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.08 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions (including lifts or ladders). Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.

1. Adjust aimable luminaires in the presence of Contract Administrator.

END OF SECTION 26 51 00

SECTION 26 56 00
EXTERIOR AREA LIGHTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This Section includes the following lighting equipment:
   1. Exterior LED light fixtures with LED modules and drivers.

1.02 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. CV: Coefficient of Variance. The ratio of standard deviation for all illuminance values to the mean illuminance value.
G. Delegated-Design Submittals: Documents, including, but not limited to, drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by Owner and authorities having jurisdiction.
H. EISA: Energy Independence and Security Act of 2007.
I. HID: High-intensity discharge.
J. Horizontal Illuminance: Measurement in foot-candles (lux), on a horizontal surface 36 inches above the ground, unless otherwise indicated.
K. L70: minimum 70% maintained initial-rated lumens at average rated life for LEDs
L. LED: Light Emitting Diode
M. 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.
N. LED Module: Light source that contains LEDs, and may include additional components such as lenses, reflectors, or refractors, however do not include drivers.
O. LER: Light fixture efficacy rating.
P. Light fixture: Complete light fixture, including ballast housing if provided.
Q. LLD: Lamp Lumen Depreciation.
R. LLF: Light Loss Factor.
S. Luminaire: Complete lighting fixture, including ballast housing if provided.
T. Pole: Light fixture support structure, including tower used for large area illumination.
U. Standard: Same definition as "Pole" above.
V. Target Illumination: Average maintained illumination level, calculated by multiplying initial illuminance by LLF.
W. UG: Uniformity Gradient; the rate of change of illuminance over a lighted area, expressed as a ration between the illuminances of adjacent measuring points on a uniform grid.
X. Vertical Illuminance: Measurement in foot-candles (lux), in two directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.

1.03 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 layout and installation of light fixtures, poles, foundations, and underground raceway system with other above- and below-grade site construction and utilities. Notify Contract Administrator of conflicts before proceeding with the Work.

1.04 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.

B. Prepare portfolios from manufacturer's standard specification sheets, and include the number indicated on the Light Fixture Schedule to identify each light fixture. Do not combine more than one light fixture type on a single sheet.

1. Fixture or other materials shall not be shipped, stored, or installed into the work without approval of shop drawings.
2. Modifications to fixtures shall be in accordance with Contract Administrator’s comments.

C. Product Data: For each light fixture, pole, and support component, arranged in order of lighting unit 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, effective projected area, 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 luminaires specified with 80 CRI or greater.
3. Light fixture mounting details, including, but not limited to, non-standard outlet boxes.
4. Construction of light fixture housing and door (if applicable).
5. 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.
    a. For dimming LED, also include dimming type technology and dimming range/limits.
6. 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.
7. Details of attaching light fixtures and accessories.
8. Details of installation and construction.

9. Photometric data, in IESNA format, including LM-79 for LED luminaires, based on laboratory tests of each light fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the light fixture as applied in this Project.
    a. For indicated light fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining light fixtures shall be certified by manufacturer.
    b. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
10. Materials, dimensions, and finishes of poles.
11. Means of attaching light fixtures to supports, and indication that attachment is suitable for components involved.
12. Anchor bolts for poles.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For light fixtures to include in operation and maintenance manuals.

F. Warranty: Special warranties specified in this Section.

1.05 SUBSTITUTIONS

A. Refer to Division 26 Section “General Electrical Requirements”.

B. Prior to the Bid Date, substitutions will not be considered unless the Contract Administrator/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 a complete description of the proposed substitute including cut sheets, photometric data, and all other information necessary for an evaluation. Provide interior point-by-point calculations 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 Contract Administrator/Engineer.

E. The Contract Administrator/Engineer have 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).

1.06 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of light fixture and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in latest AASHTO LTS-4.

B. Ice Load: As stated in latest AASHTO LTS-4 or as required by the local authority having jurisdiction, whichever is more stringent.

C. Wind Load: As stated in latest AASHTO LTS-4 or as required by the local authority having jurisdiction, whichever is more stringent.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer’s authorized representative who is trained and approved for installation of units required for this project.

B. Light Fixture Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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 C2, "National Electrical Safety Code."

E. Comply with NFPA 70.

1.08 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 1.12.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.

D. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Light fixtures: Free from defects in materials and workmanship (excluding fuses and lamps) for a period of 5 years from date of Substantial Completion.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

A. In Light Fixture Schedule (on the drawings) 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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 LIGHT FIXTURES, GENERAL REQUIREMENTS

A. Light fixtures shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IES RP-8 for parameters of lateral light distribution patterns indicated for light fixtures.

C. Comply with IES BUG ratings where indicated on the Light Fixture Schedule.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

F. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed light fixtures.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

H. Exposed Hardware Material: Stainless steel for latches, fasteners, and hinges.

I. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

J. Light Shields: Metal baffles or louvers, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

K. 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.

L. Gaskets for Lenses and Refractors: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in light fixture doors.

M. 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.

N. Light Fixture Finish: Manufacturer's standard paint applied to factory-assembled and -tested light fixture before shipping. Where indicated, match finish process and color of pole or support materials.

O. Factory-Applied Finish for Steel Light Fixtures: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
   2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As indicated on the Light Fixture Schedule.

P. Factory-Applied Finish for Aluminum Light Fixtures: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
    a. Color: As indicated on the Light Fixture Schedule.

Q. 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. “USES ONLY” and include specific lamp or LED type.
    b. LED type, wattage, beam angle (if applicable) for LED luminaires. Include maximum allowed wattage.
    c. For LED luminaires, includes CCT and CRI.

2.03 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 +/- 5% published load range.
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.
12. Suitable for use in outdoor light fixtures.
13. Dimming Drivers
    a. 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:
        1) Luminaires: 100 to 10 percent of rated lumens.

2) LED Lamps: 100 to 20 percent of rated lumens.

b. 0-10V dimming drivers: Compliant with IEC 60929 standard for 4-wire dimming.

c. Compatibility: Certified by the manufacturer for use with specific dimming control system and LED indicated.

d. Control: Coordinate to ensure that the dimming driver, power supply, controller, dimming module, and/or wallbox dimmer and connecting wiring are compatible.

2.04 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 70 CRI minimum and 4000K CCT. Additionally, color-important light fixtures, as indicated with 80 CRI or better the Light Fixture Schedule shall be 80 CRI minimum and 4000K CCT. All LEDs used for same fixture type throughout the project to originate from same production bin.

B. LED binning specification tolerance to be within 3 MacAdam ellipses of rated values for color as indicated in the Light Fixture Schedule.

C. Unless indicated otherwise in the Light Fixture Schedule, minimum 70% of maintained initial-rated lumens at the average rated life as follows:

1. LED outdoor pole mounted area lights: 100,000 hours
2. LED lamps: 20,000 hours
3. Other LED luminaires: 50,000 hours

D. ROHS compliant

E. Manufacturer of LED chips will be evaluated based on the manufacturer's product literate and data. At a minimum, LED fixtures or lamps will incorporate Bridgelux, Nichia, Cree, Xicato or Osram LEDs; additional manufacturers may be considered however the Contract Administrator or Engineer has the authority to reject other manufacturers for technical or aesthetic reasons if felt necessary or desirable.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify conditions of equipment and installation prior to beginning work.

B. Verify that equipment is ready for connecting, wiring, and energizing.

3.02 LIGHT FIXTURE INSTALLATION

A. Install lamps in each light fixture.

B. Fasten light fixture to indicated structural supports.

C. Adjust light fixtures that require field adjustment or aiming.

D. Baffles and Louvers for Spill Light Correction: Install on lighting fixtures with fasteners provided by the manufacturer. Install and adjust to correct out-of-limit spill-light measurements.

E. Auxiliary devices for low voltage and LED fixtures installation

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 undesirable, 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, but not limited to, transformers, power supplies, and drivers, per Code and manufacturer's recommendations.
5. Provide enclosures suitable for installation environment as required.

3.03 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceways and Boxes for Electrical Systems", including use of coated conduits in concrete foundations.

3.04 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Adjust all light fixture sockets to match the lamp specified and aim all adjustable light fixtures as directed by the Contract Administrator.

C. Upon completion of the installation of light fixtures, and after building circuits have been energized, apply electrical energy 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. 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.

E. At the time of Substantial Completion, aim all adjustable fixtures, such as flood and spotlights, per the Contract Administrator’s direction. Provide all necessary equipment to support this effort, such as scaffolds and lifts, as required.

F. At the time of Final Acceptance of this Project by the Owner, all lamps shall be in working order and all light fixtures shall be fully lamped.

G. Illumination Observations: Verify normal operation of lighting units after installing light fixtures and energizing circuits with normal power source.

END OF SECTION 26 56 00

SECTION 284600
FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. 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 26 Section "Common Work Results for Electrical," for materials and methods for coordination, sleeves and common installation requirements.

1.02 DESCRIPTION OF WORK

A. This Section requires the Contractor to furnish all materials required to install the fire alarm system. The Contractor shall be responsible for installing, testing, and start-up of a complete functioning fire alarm system, and each element thereof, as specified or indicated on the Drawings or reasonably inferred, including every article, device or accessory (whether or not specifically called for by item) necessary to facilitate each system's function as indicated by the design and the equipment specified. Elements of the work include materials, labor, supervision, supplies, equipment, transportation and utilities.

B. Division 28 of the Specifications and Drawings numbered with prefixes FX generally describe these systems, but the scope of the Fire Alarm work includes all such work indicated in the Contract Documents: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Fire Suppression, Mechanical, Plumbing, Fire Alarm and Electrical Drawings and Specifications; and Addenda.

C. The Drawings have been prepared diagrammatically and are intended to convey the scope of work, indicating the general location and arrangement of the major equipment, devices, appliances, etc. without showing all the exact details as to elevations, circuits, routing, and other installation requirements. Use the Drawings as a guide when laying out the system and 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. The scope of work in this section includes:

1. Manual fire alarm pull stations
2. System smoke detectors
3. Notification appliances
4. Sprinkler system waterflow and valve tamper alarms
5. Magnetic door holders
6. Air handling unit shutdown
7. Battery stand-by power
8. Multi-channel one-way voice notification system

1.03 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. Installation of devices shall be performed or supervised by a National Institute for Certification of Engineering Technologies (NICET) Level 2 or higher Fire Alarm Technician. Submit copies of the certification for employees through shop drawing submittals.

1.04 APPLICABLE CODES AND STANDARDS

A. Execute Work in accordance with the National Fire Protection Association Standards 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. 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.

1. NFPA 70, “National Electrical Code”, 2011 Edition.

3. NFPA 72, “National Fire Alarm and Signaling Code”, 2010 Edition.

4. NFPA 101, “Life Safety Code”, 2012 Edition.

5. Underwriters Laboratories, “Fire Protection Equipment Directory”, Latest Edition.

6. HCA Healthcare Design and Engineering Guidelines for Hospitals, 2021 Edition

7. International Fire Code (IFC) 20xx Edition with local amendments.

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

1.05 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. 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 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.

6. FACP: Fire Alarm Control Panel.

7. NICET: National Institute for Certification in Engineering Technologies.
8. 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”.
9. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.

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.

1.06 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 in the manner anticipated in the design.

C. The Contractor shall maintain a foreman on the jobsite at all times to coordinate their work with other contractors and subcontractors so that various components of the Fire Alarm 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.

D. 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.

E. Where coordination and interfacing with other systems or equipment is required, it shall be the responsibility of the fire alarm system installer (contractor) to either provide the relays, contacts, power supplies and other necessary hardware or see to it that such hardware is provided with the other systems or equipment.

F. The contractor shall coordinate work in this section with all related trades. Work and/or equipment provided in other sections and related to the fire alarm system shall include, but not be limited to:

1. Sprinkler waterflow and valve tamper switches shall be provided by the fire sprinkler installer, but wired and connected by the fire alarm installer.
2. Duct smoke detectors shall be furnished, wired and connected by the fire alarm system installer. The HVAC installer shall furnish necessary duct opening to install the duct smoke detector’s housing.
3. Air handling fan control circuits and contacts to be furnished by the HVAC control equipment.
4. Conduit shall be by Division 26 “Common Work Results for Electrical”.

G. 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.

1.07 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.

1.08 SUBMITTALS

A. Refer to Division 1 and General Conditions for submittal requirements, in addition to requirements specified herein. Submittals not complying fully with the submittal requirements will be rejected.

B. Contractor shall prepare installation drawings (working shop drawings) based upon this design. Requests for deviations from the approved design shall be submitted in writing to the Engineer of Record for approval.

C. Shop drawings shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code and relevant laws, ordinances, rules and regulations. Drawings that are not legible, or that do not contain sufficient detail to verify compliance with applicable codes and standards, will be rejected without further review.

D. Submittals and shop drawings shall not contain HEI's firm name or logo, nor shall it contain the HEI's engineers' seal and signature. They shall not be copies of HEI's work product. If the contractor desires to use elements of such product, the license agreement for transfer of information at the end of this section must be used.

E. Submit Shop Drawings as early as required to support the project schedule. Allow for two weeks Engineer review time plus mailing time plus a duplication of this time for resubmittal if required. Submit Shop Drawings as soon as possible before construction starts.

F. Before submitting Shop Drawings and material lists, the Contractor shall verify that the equipment submitted is mutually compatible and suitable for the intended use. Contractor shall verify that the equipment will fit the available space and allow ample room for maintenance. If the size of equipment furnished makes necessary any change in location, or configuration, submit a shop drawing showing the proposed layout.

G. Refer to Division 1 for acceptance of electronic submittals for this project. For electronic submittals, Contractor shall submit the documents in accordance with the procedures specified in Division 1. Contractor shall notify the Architect and Engineer that the shop drawings 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 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 electronic submittal and shall clearly indicate the materials, performance criteria and accessories being proposed. General product catalog data not specifically noted to be part of the specified product will be rejected and returned without review.

H. The Engineer's checking and subsequent acceptance of such submittals shall not relieve the Contractor from responsibility for deviations from Drawings or Specifications unless the Contractor has, in writing, called the Engineer's and Architect's attention to such deviations at the time of submission, and secured written acceptance; nor shall it relieve the Contractor from responsibility for errors in dimensions, details, sizes of members, or quantities; or for omissions of components or fittings; or for not coordinating items with actual building conditions and adjacent work.

I. Product Data: Provide a bill of materials and product cutsheets showing material specifications, electrical characteristics and connection requirements. Highlight or indicate specific product options and accessories as applicable to the project.

J. Shop Drawings:
   1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
   2. Shop drawings shall be prepared by a NICET Level II or higher certified technician. Submit copies of the certification for the designer with submittal.
   3. The fire alarm system equipment vendor shall provide shop drawings showing fire alarm floor plans and a full building riser diagram. Fire alarm floor plans and riser diagram shall show fire alarm control panel, annunciator, all fire alarm initiating devices and notification appliances. Show typical wiring diagrams of control panel/s, annunciator and each device and wiring connections required. Show all interfaces to other systems, such as temperature control systems, and security systems.
   4. The fire alarm floor plans and riser diagram shall show wiring to all fire alarm devices/appliances, indicating wire sizes and quantities as well as conduit/raceway sizes and locations of end-of-line (EOL) resistors. The fire alarm floor plans and riser diagram shall clearly show the routing of all fire alarm system wiring, including all horizontal routing and vertical routing (in chases).
   5. Routing of all fire alarm wiring shall comply with the “Survivability” requirements of NFPA 72.
   6. Provide a Sequence of Operations Matrix that explains how the submitted fire alarm system functions.
   7. Include voltage drop calculations for notification-appliance circuits.
   8. Include battery-size calculations.
   9. Shop drawing scale shall match the Engineer’s drawings where possible. Scale shall not be less than 3/32" = 1’-0".
   10. Shop drawings shall be produced using computer-aided design. Hand drawn documents will not be reviewed or approved.

K. Indicate within the submittal all applicable UL listings and all applicable approvals or certifications.

L. Qualification Data: Submit copies of the certification for the Installer.

M. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of products.

1.09 ELECTRONIC DRAWING FILES

A. In preparation of shop or record drawings, Contractor may, at their option, obtain electronic drawing files in AutoCAD or DXF 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. Contact the Architect for Architect’s written authorization. Contractor shall complete and send the form attached at the end of this section along with a check made payable to Henderson Engineers, Inc. Contractor shall indicate the desired shipping method and drawing format on the attached form. In addition to payment, Architect’s written authorization and Engineer’s release agreement form must be received before electronic drawing files will be sent.

1.10 SUBSTITUTIONS

A. Refer to Division 1 and General Conditions for Substitutions.

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

C. 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 calendar days prior to the date for receipt of Bids. Each such request shall include the name of the material or equipment for which it is to be substituted and a complete description of the proposed substitute including drawings, cuts, performance and test data and other information necessary for an evaluation. A statement

setting forth changes in other materials, equipment or other Work that incorporation of the substitute would require shall be included. The burden of proof of the merit of the proposed substitute is upon the proposer. The Engineer's decision of approval or disapproval to bid of a proposed substitution shall be final.

D. 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.

E. No substitutions will be considered after the Contract is awarded unless specifically provided in the Contract Documents.

1.11 OPERATION AND MAINTENANCE DATA

A. Refer to Division 1 and General Conditions for Operational and Maintenance Manuals.

B. 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.

C. The O&M Manuals shall be provided in labeled 3-ring binder with cover, binding label, tabbed fly sheets and plastic insert folders for Record Drawings. Include the following sections with the appropriate information for each section:

1. Typewritten Index.
2. Qualifications. Provide designer and installer qualification.
3. Bill of Materials. Provide complete nomenclature, model number and vendor information for all parts.
4. Operating Instructions. Complete instructions detailing operation and maintenance of all equipment installed.
5. Product Data: Provide product cutsheets for all equipment utilized and installed.
6. Riser diagram.
7. Device addresses.
8. Record copy of site-specific software.
9. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
    a. Equipment tested.
    b. Frequency of testing of installed components.
    c. Frequency of inspection of installed components.
    d. Requirements and recommendations related to results of maintenance.
    e. Manufacturer's user training manuals.
10. Manufacturer's required maintenance related to system warranty requirements.
11. Abbreviated operating instructions for mounting at fire alarm control unit and each annunciator unit.
12. Guarantee. Copy of all guarantees and warranties issued.
13. Contact list with minimum three service representative phone numbers.

1.12 RECORD DRAWINGS

A. A set of prints shall be kept on the jobsite during construction for the purpose of noting changes to location of all fire alarm equipment, devices, appliances and circuits as finally installed. During the course of construction, the Contractor shall indicate on these drawings, changes made from the Contract Drawings. Particular attention shall be made to those items which need to be located for servicing.

B. The record drawings shall show actual locations of initiating devices, notification appliances, and end-of-line devices. Show the approximate location, size and type of all wiring and routing of wiring. Drawings should also include one-line riser diagrams showing all devices.

C. The Contractor shall sign-off on the Record Drawings as being an accurate representation of the completed installation.

D. Refer to Division 1 and General Conditions for Record Drawings

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

1.13 SPARE PARTS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide 10% of the total or a minimum of one (1) manual pull station.
2. Provide 10% of the total or a minimum of two (2) of each type of automatic smoke detector.
3. Provide 5% of the total or a minimum of two (2) of each strobe type and candela rating.
4. Provide 5% of the total or a minimum of two (2) of each horn/speaker type. Combination horn/speaker/strobe units matching the units installed are acceptable.
5. Keys and Tools: One extra set for access to locked or tamper proofed components.

1.14 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products indicated in this section with minimum three years documented experience.

B. Installer: Company specializing in installing the products indicated in this section with minimum three years documented experience. Shall be bondable and licensed Contractor and employ full-time factory-trained and certified installers and technicians. Installers shall provide with the fire alarm submittal proof of factory training for each installer.

C. Final checkout and verification: Shall be conducted by a technician certified by the National Institute for Certification in Engineering Technologies (NICET) registered as level 2 or higher in the fire protection technology certification program. Provide certification information with fire alarm submittal.

D. The equipment manufacturer's service department shall be fully stocked in standard parts and components and engaged in the maintenance of fire alarm systems. On-the-premises service shall be available within 4 hours of notification, 7 days a week, 24 hours a day.

1.15 GUARANTEES AND WARRANTIES

A. Refer to Division 1 and General Conditions for Guarantees and Warranties.

B. Furnish service and maintenance of fire alarm system including wiring and raceways for one year from date of substantial completion.

C. All components, system software, parts and assemblies shall be guaranteed against defects in materials and workmanship for the one-year period stated above, unless specific items are noted to carry a longer warranty in the Construction Documents or manufacturer's standard warranty.

D. Labor (including travel expenses) to trouble-shoot, repair, reprogram, or replace components shall be furnished by this contractor at no charge during the warranty period.

E. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software.

1.16 PROJECT 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, the Contractor shall visit the Site prior to submitting a 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 Fire Alarm Contractor shall perform the demolition which involves fire alarm system equipment and materials.
4. Fire Alarm Contractor shall remove articles which are not required for the new work. Unless otherwise indicated, each item removed by the Contractor during this demolition shall be removed from the premises and disposed of in accordance with applicable federal, state and local regulations.
5. Fire Alarm Contractor shall relocate and reconnect fire alarm equipment that must be relocated in order to accomplish the remodeling shown in the Drawings or indicated in the Specifications. General Contractor shall install finish material.
6. Obtain permission from the Architect for channeling of floors or walls not specifically noted on the Drawings.
7. 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.
8. Locate, identify, and protect Fire alarm 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. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

C. Interruption of Existing Fire alarm Service: Do not interrupt fire alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire watch service according to local Fire Department requirements:
1. Notify Architect no fewer than five days in advance of proposed interruption of fire alarm service.
2. Do not proceed with interruption of fire alarm service without Owner’s written permission.

D. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.17 SEQUENCING AND SCHEDULING

A. Existing Fire alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire alarm system, remove all unused fire alarm equipment, wiring and installation materials not necessary for system functionality or spare parts.

PART 2 - PRODUCTS AND MATERIALS

2.01 SYSTEM DESCRIPTION

A. Noncoded, UL-listed addressable system, with multiplexed signal transmission and voice/strobe evacuation.

B. All components provided shall be listed for use with the selected system.

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. Source Limitations for Fire alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested, and will operate, as a system.

2.02 MANUFACTURER

A. Subject to compliance with requirements, provide products manufactured by the following manufacturers compatible with the existing system.

2.03 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire alarm signal initiation shall be by one or more of the following devices.
   1. Manual pull stations.
   2. Smoke detectors.
   3. Automatic sprinkler system water flow.

B. iFire alarm signal shall initiate the following actions:
   1. Identify alarm and specific initiating device at fire alarm control unit and remote annunciators (if provided).
      a. A pulsing alarm tone shall occur within the control panel until acknowledged.
      b. The alarm LED shall flash on the control panel and remote annunciator panel until the alarm has been acknowledged at the control panel/remote annunciator panel. Once acknowledged, this same LED shall latch on and the custom label for the address in alarm shall be displayed on the alphanumeric LCD readout. A subsequent alarm received from another address after acknowledged shall flash the alarm LED on the control panel showing the new alarm information.
   2. Transmit an alarm signal to the alarm supervising station.
   3. Audible notification appliances shall sound until silenced by the alarm silence switch at the control panel.
   4. All visible alarm notification appliances shall display a continuous synchronized pattern until reset by the Alarm Reset Switch.
   5. Record events in the system memory.
   6. Unlock electric door locks in designated egress paths.
   7. Release fire and smoke doors held open by magnetic door holders.
   8. Activate voice/alarm communication system.
   9. All fan-powered air-handling equipment shall shutdown and remain down until the fire alarm control panel is reset.
   10. Close smoke dampers in air ducts of designated air-conditioning duct systems.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
   1. Valve supervisory switch.
   2. Duct-smoke detectors
   3. User disabling of zones or individual devices.
   4. Loss of communication with any panel on the network.

D. System Supervisory Signal Actions:
   1. Identify specific device causing supervisory signal fire alarm control unit and remote annunciators (if provided).
      a. Visible and audible supervisory alarm indicated by address at fire alarm control panel.
      b. Manual acknowledge function at fire alarm control panel and remote annunciator panel silences audible supervisory alarm; visible alarm is displayed until device is returned to its normal position/supervisory condition is cleared.
   2. Record events in the system memory.
   3. After a time delay of 90 seconds transmit a supervisory signal to the alarm supervising station.
   4. Transmit system status to building management system.
   5. Display system status on graphic annunciator.

6. Duct-mounted smoke detectors shall shutdown their respective unit upon detection of smoke and remain down until manually reset.
7. Individual fan-powered air distribution equipment less than 2,000 cfm that is not provided with duct detection shall shutdown when the respective air handling unit is shutdown.

E. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire alarm control unit.
5. Ground or a single break in internal circuits of fire alarm control unit.
6. Abnormal ac voltage at fire alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire alarm control unit or annunciator.
10. Voice signal amplifier failure.

F. System Trouble Signal Actions:
1. Identify specific device causing trouble signal fire alarm control unit and remote annunciators (if provided).
a. Visible and audible trouble alarm indicated by address at fire alarm control panel.
b. Manual acknowledge function at fire alarm control panel and remote annunciator panel silences audible trouble alarm; visible alarm is displayed until device is returned to its normal position/trouble condition is cleared.
2. Record events in the system memory.
3. After a time delay of 90 seconds, transmit a trouble signal to the alarm supervising station.
4. Transmit system status to building management system.
5. Display system status on graphic annunciator.

2.04 FIRE ALARM SYSTEM CONTROL UNIT

A. Fire Alarm Panel existing to remain.

a.

B. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Sealed lead acid.
2. The secondary power system shall operate system in standby mode for 24 hours followed by alarm mode for 15 minutes.

2.05 EMERGENCY VOICE/ALARM COMMUNICATIONS SYSTEMS (EVACS):

2.06 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter (DACT) is existing to remain.

2.07 INITIATING DEVICES

A. Manual Fire Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double action mechanism requiring two actions to initiate an alarm, pull lever type; with integral addressable module arranged to communicate manual station status (normal, alarm, or trouble) to fire alarm control unit.
2. Station Reset: Key or wrench operated switch.
3. Indoor Protective Shield: Factory fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

B. System Smoke Detectors: Photoelectric type complying with UL 268 operating at 24-V dc, nominal with integral addressable module arranged to communicate detector status (normal, alarm, or trouble) to fire alarm control unit.
1. Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base.
2. Device shall have an integral visual-indicating light, LED type, indicating detector has operated and power-on status.
3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Photoelectric detectors shall have sensitivity between 0.5 and 3.5 percent/foot smoke obscuration.

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A with a standard, relay or isolator detector mounting base. Provide manufacturer's standard housing to protect the measuring chamber from damage and insects. Provide drilling templates and gaskets to facilitate locating and mounting the housing.
1. Provide for variations in duct air velocity between 100 and 4,000 feet per minute.
2. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied. Provide an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet.
3. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
4. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor control circuit.
5. Provide remote alarm LEDs and remote test stations as shown on the plans.
6. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.

2.08 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
1. Combination Devices: Factory integrated audible and visible devices in a single mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections. Minimum audible level and strobe intensity shall meet all requirements for separate appliances.
2. Provide strobe synchronization as required per NFPA 72.
3. Wall mounted notification appliances shall be manufacturer standard and match existing finish.
4. Ceiling mounted notification appliances shall be manufacturer standard and match existing finish.

B. Alarm Speakers: Comply with UL 1480. High quality tone and voice reproduction; capacitor connected for connection to supervised notification appliance circuit; semi-flush mounting; four inch cone; high impact, flame retardant PC/ABS thermoplastic; 25 or 70 VRMS; multi-tapped output power rated ¼ to 2 watts and produce 79 to 88 dB at 10 feet.

C. Special Application Speakers (Wall Mount):

1. Atlas/Soundolier voice control loudspeaker, model number APF-15TU. Model shall be a double re-entrant type with 15 watts RMS audible power rating compression driver producing a UL-rated sound pressure level of 102 dB measured at 15 watts at 10 feet, within a frequency range of 400 Hz to 4 kHz. Loudspeaker assembly shall be furnished with mounting bracket allowing adjustment on either a vertical or horizontal plane with a single locking pin and including provisions for mounting, banding or strapping. Wiring terminals for amplifier output shall be fully enclosed and vandal–resistant adapter cover shall provide connection facilities for cable or conduit. Unit shall be finished in red baked epoxy.
2. Wheelock ET 1010 Speaker - vandal resistant loud speaker. Speaker includes both 25 and 70 volt VRMS inputs with field selectable power taps from 1/8 to 8 watts with listed sound output up to 96 dB for speakers. All models shall have provisions for standard NAC supervision and IN/OUT field wiring using terminals that accept #12 to #18 AWG wiring.

D. Visible Alarm Notification Appliances (Strobes): Xenon strobe lights complying with UL 1971, unfiltered or clear filtered white light, with candela ratings as indicated on drawings. Strobes shall meet all requirements of the Americans with Disabilities Act.

2.09 AUXILIARY DEVICES

A. Magnetic Door Holders: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 120-V ac.

B. Waterflow Alarm Switches: Shall be provided by the Fire Sprinkler Installer and shall be wired complete and ready for use by the Fire Alarm System Installer. Switch shall have an adjustable delay to minimize false alarms due to fluctuations in water pressure.

C. Valve (Tamper) Switches: Shall be provided by the Fire Sprinkler Installer and shall be wired complete and ready for use by the Fire Alarm System Installer.

D. Monitor Module: Addressable microelectronic module providing a system address for alarm initiating devices for wired applications with normally open contacts. Include address setting means on the module.

E. Control/Relay Module: Provide intelligent control relay modules. The Control Relay Module shall provide one form “C” dry relay contact rated at 2 amps @ 24 VDC to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware.

2.10 FIRE ALARM WIRE AND CABLE

A. Fire Alarm Power Branch Circuits: Building wire as specified in Division 26.

B. Fire alarm Wire and Cable: NRTL listed and labeled as complying with NFPA 70 (NEC) Article 760. All wiring, including wiring to existing modified devices and appliances shall be new.

C. Signaling Line, Initiating Device and Notification Appliance Circuits: Power limited fire protective signaling cable, solid copper conductor, 300 volts insulation, suitable for temperature, conditions and location installed. Minimum wire size for initiating device circuits, control circuits and notification appliance circuits shall be determined by calculations and manufacturer’s requirements or recommendations. Wire and cable shall be twisted and shielded if recommended by the system manufacturer.

D. The type of cable chosen should be based on fire alarm system requirements, specification requirements and applicable code requirements. Consideration should also be given to the length of cable runs and potential interference.

E. Initiating, notification, and control circuits shall be sized based on 20% additional power consuming devices.

F. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems.

G. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.

H. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket and red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated.

I. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits: Provide circuitry, which meets the performance requirements during abnormal conditions, based upon the class of the circuitry selected.

1. Initiating Device Circuits: Match existing circuits.
   a. Pathway Survivability: Match existing circuits .
2. Notification Appliance Circuits: Match existing circuits.
   b. Pathway Survivability: Match existing circuits
3. Signaling Line Circuits: Match existing circuits.
   c. Pathway Survivability: Match existing circuits
4. Any circuits interconnecting fire alarm control panels between separate buildings shall be provided with surge protection.

2.11 ACCESS TO EQUIPMENT

A. All detectors, modules, equipment, etc. shall be located so as to provide easy access for operation, service inspection and maintenance.

B. Access Doors:

1. Provide access doors for all concealed equipment, except where above lay-in ceilings.
2. Access doors shall be adequately sized for the devices served with a minimum size of 18" x 18", furnished by the respective Contractor or Subcontractor and installed by the General Contractor.
3. Access doors must be of the proper materials 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 gypsum wallboard or plaster: perforated flanges with wallboard bead.
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.
9. Locking Devices: Where indicated on the drawings or where access panels are installed in locations accessible to the public, provide 5-pin or 5-disc type cylinder locks, individually keyed; provide 2 keys.
10. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
    a. Arrow United Industries.

b. Bar-Co., Inc.
c. J.L Industries.
d. Karp Associates, Inc.
e. Milcor Div. Inryco, Inc.
f. Nystrom Building Products
g. Wade
h. Zurn

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall install, program and test all new equipment identified in this contract and revise existing equipment as noted in accordance with the applicable codes, standards, and manufacturer's instructions.

B. The installation supervisor shall be on the job site during the entire installation. The installation supervisor shall maintain marked up copies of the drawings at the job site showing as-built conditions. These drawings shall be updated daily and available for Owner review.

C. The Contractor shall provide all required conduit and all associated hardware, and shall install (pull), connect, and test all cable for a complete fire alarm system. All wiring shall be installed in accordance with the guidelines of these specifications and documents as well as the NFPA codes and standards listed in these specifications.

3.02 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.03 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 and requirements of authorities having jurisdiction for installation and testing of fire alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel.
2. Expand, modify, and supplement existing control/monitoring equipment as necessary to extend existing functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 72 inches above the finished floor.

D. Manual Fire alarm Boxes: Provide manual fire alarm boxes as shown on drawings. Mount manual fire alarm box on a background of a contrasting color. The operable part of manual fire alarm box shall be at 48 inches above floor level unless noted otherwise.

E. Smoke : Provide detectors as shown on drawings.
   1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke detector spacing.
   2. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
   3. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
   4. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
   5. Install ceiling mounted detectors in areas with exposed structure tight to underside of floor/roof deck unless noted otherwise on drawings.

F. Duct Smoke Detectors: Comply with NFPA 72. Install sampling tubes so they extend the full width of the duct. Tubes more than 36 inches long shall be supported at both ends.
   1. Do not install smoke detector in duct smoke detector housing during construction. Install detector only during system testing and prior to system turnover.
   2. Provide duct detection and shutdown for fan powered air distribution equipment exceeding 2,000 cfm.
   3. Provide equipment and connections to shutdown fan powered air distribution equipment with a capacity less than 2,000 cfm that are part of an air distribution system with a capacity greater than 2,000 cfm.

G. Single Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, or valve-tamper switch that is not readily visible from normal viewing position.

I. Install ceiling mounted visible and audible/visible notification appliances in areas with exposed structure to bottom of floor/roof structure or at 30 ft AFF, whichever is lower.

J. Install ceiling mounted visible and audible/visible notification appliances in areas with finished ceilings flush with bottom of ceiling or at 30 ft AFF, whichever is lower.

K. Install wall mounted visible and audible/visible notification appliances with visible element (strobe) between 80 inches and 96 inches above finished floor unless noted otherwise on drawings.

L. Install wall mounted audible devices with the top of the device at least 90 inches above finished floor or 6 inches below the ceiling, whichever is lower, unless noted otherwise on Drawings. If combination devices are installed, they shall be installed per the visible signal device requirements.

M. All notification appliance speakers shall be tapped at ½ watt unless noted otherwise on drawings. In rooms less than 100 sq ft, speakers are permitted to be tapped at ¼ watt.

N. Mount outlet box for electric door holder to withstand 80 pounds (36.4 kg) pulling force.

3.04 PATHWAYS

A. Pathways above suspended ceilings and in nonaccessible locations may be routed exposed where permitted by NFPA 70 & 72.
   1. Exposed pathways located less than 96 inches above the floor shall be installed in conduit.

B. Pathways shall match existing.

C. All detection and control circuits associated with smoke control systems shall be fully enclosed within continuous raceways.

D. Minimum allowable conduit size shall be ¾ inch. The conduit shall be sized so that conduit fill does not exceed 75% of NFPA 70 maximum fill requirements. Cables in vertical risers shall not exceed 50% of NFPA 70 maximum fill requirements. Conduit installation shall be as required by the Contractor's layout and as described in these specifications. All conduit field routing shall be acceptable to the Owner. Routing not acceptable shall be rerouted and replaced without expense to the Owner.

E. All wire, cable, conduit and raceways shall be concealed in walls, ceiling spaces, electrical shafts or closets in finished areas except as specifically noted otherwise. Conduit and raceways may be exposed in unfinished areas or where specifically approved by the Owner.

F. Except as otherwise specified or indicated on the drawings, all conduit shall be installed parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. Except where prevented by the location of other work, a single conduit or a conduit group shall be centered on structural members.

G. Conduit shall be located at least six inches from hot water or steam pipes, and from other hot surfaces. Conduit shall not block access to any existing equipment or fixtures.

H. Mount end-of-line device in box with last device or separate box adjacent to last device in circuit for conventional hardwired class B initiating and notification appliance circuits.

I. Conduit shall be securely fastened to all boxes and cabinets. Threads on metallic conduit shall project through the wall of the box to allow the bushing to butt against the end of the conduit. The locknuts both inside and outside shall then be tightened sufficiently to bond the conduit securely to the box. Conduit shall enter cabinets from the bottom and sides only.

3.05 CONNECTIONS

A. All wiring shall be terminated at devices or panels using terminal connectors for screw type terminals. All terminal connectors for conductors shall be pre-insulated ring type or pre-insulated spade type. Pre-insulated terminal connectors shall include a vinyl sleeve, color coded to indicate conductor size. Pre-insulated terminal connectors shall include a metallic support sleeve bonded to the vinyl-insulating sleeve and designed to grip the conductor insulation.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm initiating connection to smoke control system (smoke management) at firefighters' smoke control system panel.
2. Alarm initiating connection to stairwell and/or elevator shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC systems.
4. Provide equipment and connections to shutdown fan powered air distribution equipment with an individual capacity less than or equal to 2,000 cfm that are part of an air distribution system with a design capacity greater than 2,000 cfm.
5. Magnetically held-open doors.
6. Electronically locked doors and access gates.
7. Alarm initiating connection to elevator recall system and components.
8. Alarm initiating connection to activate emergency lighting control.
9. Connection to disable sound systems upon alarm activation.
10. Supervisory connections at valve supervisory switches.
11. Supervisory connections at low-air pressure switch of each dry-pipe sprinkler system.
12. Supervisory connections at elevator shunt-trip breaker.

13. Data communication circuits for connection to building management system.
14. Supervisory connections at fire pump power failure including a dead-phase or phase-reversal condition.
15. Supervisory connections at fire pump engine control panel.

3.06 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.

3.07 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. All conduits and junction boxes shall be labeled as specified in Division 26 (red).

C. The location of end-of-line resistors shall be identified with a label indicating “EOL.”

D. Provide label at each initiating device indicating the device address. Label shall be visible from the floor below or immediately adjacent to the device.

3.08 GROUNDING

A. Ground fire alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.09 FIELD QUALITY CONTROL

A. Systems shall be checked and tested in accordance with the instructions provided by the manufacturer to insure that the system functions as required and is free of grounds, opens, and shorts. Each device shall be tested.

1. Smoke detectors shall be tested with products of combustion.

B. Upon completion of the system installation and before the Date of Final Acceptance, a factory-trained technician shall perform all necessary tests and adjustments and shall then file a Letter of Certification and a Certificate of Completion (NFPA 72) with the Owner indicating that the system functions and conforms to the Fire Alarm System Specifications.

C. Upon completion of the system installation, a factory-trained technician shall perform all necessary tests and adjustments in the presence of the Owner’s designated personnel. Test in accordance with NFPA 72 and requirements of the authority having jurisdiction. Perform the following tests at a minimum:

1. Visual Inspection: Conduct visual inspection prior to testing. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    a. Test audible appliances for the public operating mode according to manufacturer's written instructions.
    b. Test visible appliances for the public operating mode according to manufacturer's written instructions.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire alarm system will be considered defective if it does not pass tests and inspections.

F. Include services of factory trained and certified technician to supervise installation, adjustments, final connections, and system testing as performed by the fire alarm contractor’s factory-trained technicians.

3.10 DEMONSTRATION

A. The equipment supplier's factory trained technician shall train the Owner's personnel in the proper use and maintenance of the system. Training sessions shall be conducted as needed, not to exceed a total of 2 sessions, with each session lasting a maximum of 4 hours each.

B. Demonstrate normal and abnormal modes of operation, and required responses to each.

C. 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.

END OF SECTION 284600