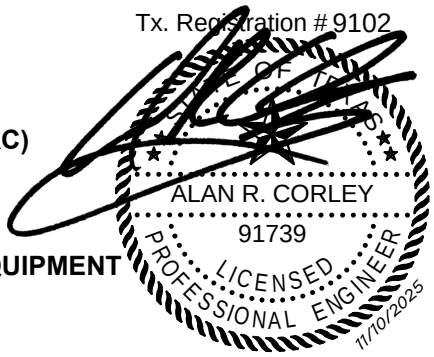

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SECTION 23 0010
BASIC MECHANICAL REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes general administrative, quality, coordination, and execution requirements for Division 23 mechanical work.

B. This Section supplements Division 01 and governs the Work of all Division 23 Sections unless a more stringent requirement is stated elsewhere.

C. Related work of other Divisions applies to this Section, including Division 01 (General Requirements), Division 07 (Thermal/Acoustical Insulation and Firestopping), Division 08 (Access Doors and Panels), Division 21/22 (as applicable), and Division 26 (Electrical).

1.02 REFERENCES (LATEST EDITION UNLESS NOTED)

A. Where differences between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents occur, the most stringent shall govern. The Contractor shall promptly notify the Owner and the Engineer in writing of any such difference.

B. Should the Contractor perform any Work that does not comply with local codes, laws and ordinances, industry standards or other governing regulations, the Work shall be corrected on noncompliance deficiencies with the Contractor bearing all costs.

C. Welding and Pressure Piping: Qualify welding per AWS D1.1/D1.1M (steel), ASME BPVC-IX (welding/brazing), and comply with ASME B31.9 for building services piping.

D. UL Listing: Where a UL standard exists for an item, provide listed and labeled products.

E. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, AWWA Specifications, Federal Standards or other standard specifications must comply with latest editions except where specified otherwise in individual Sections, revisions, amendments, or supplements in effect on date bids are received.

F. Requirements in reference specifications and standards are minimums for all equipment, materials and work. In instances where capacities, size or other features of equipment, devices, or materials exceed these minimums, meet listed or shown capacities.

G. In addition to the aforementioned ordinances, industry standards published by the following organizations shall apply:
   1. AIA: American Institute Of Architects
   2. AABC: Associated Air Balance Council
   3. AASHO: American Association Of State Highway Officials
   4. ACI: American Concrete Institute
   5. ADC: Air Diffusion Council
   6. AGA: American Gas Association
   7. AISC: American Institute Of Steel Construction
   8. AMCA: Air Moving And Conditioning Association
   9. ANSI: American National Standards Institute
   10. API: American Petroleum Institute
   11. ARI: Air Conditioning & Refrigeration Institute
   12. ASCE: American Society Of Civil Engineers
   13. ASHRAE: American Society Of Heating, Refrigerating And Air Conditions Engineers, Inc.
   14. ASME: American Society Of Mechanical Engineers
   15. ASTM: American Society For Testing And Materials
   16. AWSC: American Welding Society Code
   17. AWWA: American Water Works Association
   18. CISPI: Cast Iron Soil Pipe Institute

19. CTI: Cooling Tower Institute
20. FM: Factory Mutual
21. IRI: Industrial Risk Insurers
22. NBS: National Bureau Of Standards
23. NFPA: National Fire Protection Association
24. PDI: Plumbing And Drainage Institute
25. SMACNA: Sheet Metal And Air Conditioning Contractors National Association
26. UL: Underwriter's Laboratories

H. Where the Documents exceed the above requirements, the Documents shall govern. In no case shall Work be installed contrary to or below the minimum legal standards.

I. ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).

J. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges; 2021.

K. ASME B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series); 2012 (Reaffirmed 2021).

L. ASME B31.9 - Building Services Piping; 2025.

M. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2025.

N. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2024.

O. ASTM B32 - Standard Specification for Solder Metal; 2020.

P. ASTM B813 - Standard Specification for Water Flushable Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2024.

Q. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings; 2023.

R. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink); 2020.

S. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2021a.

T. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems; 2020 (Reapproved 2024).

U. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings; 2007 (Reapproved 2023).

V. ASTM D2846/D2846M - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems; 2024.

W. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets; 2020 (Reapproved 2024).

X. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals; 2019 (Reapproved 2025).

Y. ASTM F402 - Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings; 2018.

Z. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings; 2022.

AA. ASTM F656 - Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings; 2021.

BB. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.

CC. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2025.

DD. AWS D10.12M/D10.12 - Guide for Welding Mild Steel Pipe; 2000.

EE. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings; 2021.

FF. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

GG. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; 2006.

1.03 DEFINITIONS

A. This section includes the following definitions that are common to most Division 23 specifications.
   1. Definitions found within this section, Division 23 “Common Work Results for HVAC,” are considered to generally apply to all sections unless otherwise noted.
   2. Other sections may increase or decrease the scope and usage of a particular word, phrase, or abbreviation for the section in which it appears.

B. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 01.

C. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.

D. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self-explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by the latest ASHRAE Fundamentals Handbook, chapter 34 "Abbreviations and Symbols", ASME and ASPE published standards.

E. **AHJ:** Authority Having Jurisdiction. This abbreviation is the general term for all agencies having oversight and/or inspection authority for a scope of work, trade, or system. AHJ includes agencies such as local and state fire marshals, city inspectors, et al.

F. **AHU:** Air handling unit. This abbreviation is the general term for systems that filter and/or changes the sensible and/or latent properties of air supplied to a space. Its use is synonymous with RTU, roof top unit, irrespective of a system’s physical location.

G. **Bound Material:** Bound refers to materials permanently bound, as by stitching or glue, or materials securely fastened in their covers by multiple fasteners that penetrate all papers. Ring binders, spiral binders, brads and screw posts are acceptable fasteners. Loose papers clipped together or stapled at one corner are not acceptable.

H. **Business Day:** Where this Section and other Sections of this Division use the term “Business Day” it shall mean Monday thru Friday, excluding Holidays recognized by Federal, State and Local government.

I. **CAV:** Constant air volume.

J. **Concealed, Interior Installations:** Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

K. **Concealed, Exterior Installations:** Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

L. **Diagrammatic:** Drawings indicate general routing and relationships only; provide fittings, offsets, transitions, and accessories required for complete, code-compliant installation.

M. **Directed:** Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.

N. **Finished Spaces:** Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

O. **Exposed, Exterior Installations:** Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

P. **Exposed, Interior Installations:** Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

Q. **Finished Spaces:** Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

R. **Furnish:** Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.

S. **Galvanized:** the term “galvanized” means hot dip galvanized not electro-galvanized.

T. **Imperative Language:** Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor or, when so noted, by other identified installers or entities.

U. **Indicated:** The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.

V. **Install:** Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.

W. **Installer:** Entity (person or firm) engaged by the Contractor, or its Subcontractor or Sub-subcontractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.

X. **Like items:** of a single manufacturer unless noted otherwise.

Y. **Minimum Quality/Quantity:** In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum

(within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.

Z. **NPS:** Nominal Pipe Size.

AA. **Provide:** Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.

BB. **Reviewed:** Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.

CC. The following are industry abbreviations for plastic materials:
1. **CPVC:** Chlorinated polyvinyl chloride plastic.
2. **PE:** Polyethylene plastic.
3. **PVC:** Polyvinyl chloride plastic.

DD. The following are industry abbreviations for rubber materials:
1. **EPDM:** Ethylene Propylene diene Terpolymer rubber.
2. **NBR:** Acrylonitrile-butadiene rubber.

1.04 GENERAL REQUIREMENTS

A. All work shall comply with the General and Supplementary Conditions of the Contract.

B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings is deemed necessary by the Contractor, details of such departures and the reasons, therefore, shall be submitted to the Engineer for review as soon as practicable. No such departures shall be made without the prior written approval of the Engineer.

C. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, such reference shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Engineer, expressed in writing, is the equivalent of that specified.

1.05 SCOPE OF WORK

A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form complete and functioning systems in all of their various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The Contractor shall review all pertinent drawings, including those of other contracts, prior to commencement of Work.

B. This Division requires the furnishing and installing of all items as specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; 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, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.

C. The approximate locations of Mechanical (HVAC) items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building

and will in all cases be subject to the review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.

D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.

E. Contract drawings are schematic and do not provide final dimensions or routing. Verify all dimensions via field measurements and submit detailed coordination drawings (LOD 300) for approval prior to fabrication.

F. All discrepancies between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to bidding. Where this cannot be done at least 7 working days prior to bid; the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.

G. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.

H. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".

I. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.

J. The Contractor shall participate in the commissioning process as required; including, but not limited to, meeting attendance, completion of checklists, and participation in functional testing.

K. All work in these Sections shall be installed by craftsmen skilled in their trade.

L. Provide cutting and patching, for the Mechanical Work.

M. Provide piping from plumbing terminations, 10 feet from equipment, for water, gas, compressed air and as indicated.

N. Provide drainage from noted equipment to floor drains, roof drains, sink, or funnel drains.

O. Provide piping connections to equipment, as required, for kitchens, laboratories, laundries, and as indicated.

P. Commissioning of a system or systems specified in this section is part of the construction process.
   1. Documentation and testing of these systems, as well as training of the Owner’s operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent.
   2. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Division 01, General Commissioning, for detailed commissioning requirements.

1.06 CODE REQUIREMENTS AND PERMITS

A. It shall be the Contractor's duty to perform the work and provide the materials covered by these specifications in conformance with all ordinances and regulations of all authorities having jurisdiction.

B. All work herein shall conform to all applicable laws, ordinances, and regulations of the local utility companies.

C. Codes and standards referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes and regulations, the drawings, and specifications govern.

D. Resolve any code violation discovered in contract documents with the Engineer prior to award of the contract. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.

E. Permits/Fees/Inspections: Obtain and pay for all permits, inspections, and certificates of approval required by Authorities Having Jurisdiction.

F. Work in Occupied Facilities: Coordinate shutdowns at least 72 hours in advance; maintain services via temporary connections as needed; protect occupants and property.

G. The Contractor shall verify the current adopted versions of the following codes applicable to the project jurisdiction, including local amendments:
   1. 2021 International Mechanical Code with Local Amendments
   2. 2021 International Building Code with Local Amendments
   3. 2015 International Energy Conservation Code with Local Amendments
   4. 2023 National Electric Code with Local Amendments
   5. 2021 International Fire Code, Including Appendix J, with Local Amendments

1.07 DRAWINGS AND SPECIFICATIONS

A. The inter-relation of the specifications, the drawings, and the schedules are as follows:
   1. The specifications provide the written requirements for the quality, standard, nature of the materials, equipment and construction systems.
   2. The drawings establish the quantities, approximate dimensions, details and location of equipment.
   3. The schedules give the capacities, characteristics and components.

B. The Contract Documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. Reviewed and coordinated shop drawings developed from the BIM model shall serve as the basis for field installation. Drawings must include spatial coordination with all adjacent disciplines.

C. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the Work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.

D. For any individual project, if there is conflict between the drawings and or specifications, they are equivalent in authority and priority. Should they disagree in themselves, or with each other, prices shall be based on the most expensive combination of quality and quantity of work indicated. In the event of the above mentioned disagreements the resolution shall be determined by the Engineert.

E. Contractor is responsible to bring any conflicts in drawings and/or specifications to the attention of the Engineer, immediately, prior to any work being done.

F. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is the equivalent of the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturer’s standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.

G. The Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.

H. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.

I. Review all construction details illustrated on the architectural and structural drawings and be guided thereby.

J. All duct or pipe or equipment locations as indicated on the documents do not indicate every transition, offset, or exact location. All transitions, offsets, clearances and exact locations shall be established by actual field measurements, coordination with the structural, architectural and reflected ceiling plans, and other trades. Submit shop drawings for review.

K. All transitions, offsets and relocations as required by actual field conditions shall be performed by the Contractor at no additional cost to the Owner.

L. Additional coordination with electrical contractor may be required to allow adequate clearances of electrical equipment, fixtures and associated appurtenances. Contractor to notify Engineer of unresolved clearances, conflicts or equipment locations.

M. Equipment with electrical characteristics differing from those specified (including higher ratings) may be furnished only if approved in writing by the Architect/Engineer. Contractor shall modify all affected electrical services, circuit breakers, wiring, and conduit sizes at no additional cost to Owner; minimum efficiency requirements still apply.

1.08 SITE VISIT AND FAMILIARIZATION

A. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make do provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.

B. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.

C. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.09 SUBMITTALS

A. Coordinate with Division 01 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded. The Contractor shall submit an electronic copy of a complete set of shop drawings and complete data covering each item of equipment or material. The submittal of each item requiring a submittal must be received by the Engineer within the above thirty-day period. The Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Engineer will retain a copy of all shop drawings for their files. All literature pertaining to items subject to Shop Drawing submittal shall be submitted at one time. Submit shop drawings and product data in a single PDF file with digital bookmarks for each specification section; coordinate format with project BIM execution plan. Individual electronic files of submittals for individual specifications shall not be permitted. Each submittal shall include the following items:

1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
2. An index page with a listing of all data included in the Submittal.
3. A list of variations page with a listing of all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "**NO VARIATIONS**". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.

4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of 1/4" = 1'-0", as required to demonstrate that the alternate or substituted product will fit in the space available.
6. Identification of each item of material or equipment matching that indicated on the Drawings.
7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.
8. Additional information as required in other Sections of this Division.
9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "**REVISE AND RESUBMIT**".

B. Refer to Division 00 and Division 01 for additional information on shop drawings and submittals.

C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.

D. Where shop drawings and submittals are marked "**REVIEWED**", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.

E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:
1. **REVIEWED**: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.
2. **REVIEWED AS NOTED**: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The Contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.
3. **NOT APPROVED**: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or Drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.
4. **REVISE AND RESUBMIT**: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.
5. **CONTRACTOR'S CERTIFICATION REQUIRED**: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required stating that the submittal meets all conditions of the Contract Documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.
6. **MANUFACTURER NOT AS SPECIFIED**: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked

manufacturer not as specified. The Contractor will automatically be required to furnish the product, material or method named in the Specifications. Contractor shall not order equipment when submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.

F. Materials and equipment which are purchased or installed without submittal review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Engineer.

G. Delegated Design Submittals: Submit signed/sealed calculations and details for equipment anchorage and housekeeping pad anchors in accordance with ASCE 7 and applicable code.

H. O&M Data: Provide operation and maintenance manuals including startup procedures, recommended maintenance, replacement parts lists, and warranty information.

I. Closeout Submittals: Submit manufacturer warranties, startup reports, TAB reports, commissioning documentation, duct leakage test reports, and record drawings.

J. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.

K. Submittals are required for, but not limited to, the following items subject to project requirements:
   1. Coordination Drawings
   2. Common Motor Requirements for HVAC Equipment
   3. Variable Frequency Motor Speed Control for HVAC Equipment
   4. Hangers and Support for Piping and Equipment HVAC
   5. Vibration and Seismic Controls for HVAC Piping and Equipment
   6. Testing, Adjusting, and Balancing
   7. HVAC Equipment Insulation
   8. HVAC Piping Insulation
   9. Energy Management and Control System
   10. Above Ground Hydronic Piping
   11. Hydronic Specialties
   12. Hydronic Pumps

L. Refer to other Division 23 sections for additional submittal requirements. Provide samples of actual materials and/or equipment to be used on the Project upon request of the Owner or Engineer.

1.10 COORDINATION DRAWINGS

A. Prior to starting work, the Contractor shall provide coordination drawings for all areas of the building. The Contractor shall submit the coordination drawing for confirmation of the coordination process. The Contractor is responsible for all trade confirmation.

B. Contractor may not proceed with construction of MEP systems until trade coordination process has been demonstrated to be completed by the Contractor to the Engineer and Owner.

C. Prepare drawings showing dimensioned layout for the following:
   1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between structural components and other adjacent building elements, including but not limited to pre-tensioning and post-tensioning members where used.
   2. Reflected Ceiling Plans: Ceiling plans, sections, and other necessary details showing layouts for equipment located in or on the ceiling plane. Base dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Include all items in the ceiling plane coordinated with each other, based on input from installers of the items involved.

3. Sheet Metal and Duct Systems, including all underfloor work (prepared at a minimum scale of 1/8"=1'-0")
4. Piping and equipment systems for chilled water, condenser water, refrigerant, heating water, steam and other HVAC piping systems. (Preferably at 1/4” = 1’ – 0” and not less than 1/8” = 1’ – 0”).
5. Equipment room layouts with actual equipment, piping, and duct at 1/4” = 1’ – 0” scale. Show clearances, access spaces, relative heights of piping, main ducts, outside and relief louvers. Provide at least one section through each equipment room showing the same.
6. Temperature Control Diagrams with Sequence of Operations on same drawing.
7. Housekeeping and equipment concrete pads.
8. Dimensioned floor drain locations and the equipment each serves.
9. Roof layouts.
10. Trench locations and sizes.
11. Equipment support locations, type of support, and weight on each support.
12. Location of structural supports for structure-supported raceways.
13. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

D. The following items shall be coordinated with each other, based on input from installers of the items involved:
1. Suspended ceiling components.
2. Structural members to which suspension systems for luminaires will be attached.
3. Perimeter moldings, decorative ceiling elements, and Architectural features.
4. Luminaires.
5. HVAC Diffusers, Registers and Grilles.
6. Speakers.
7. Sprinklers.
8. Fire Alarm initiating devices, including but not limited to the following:
   a. Smoke detectors.
   b. Heat detectors.
9. Fire Alarm notification appliances.
10. Occupancy sensors.
11. Access panels.
12. Security cameras and occupancy detectors.
13. Wireless Access Points.
14. Cable Tray.
15. Roof curbs.

E. CAD / BIM:
1. Provide 1/4-inch scale fully coordinated 3D drawings based on federated BIM models. Confirm trade coordination via clash detection reports prior to submittal.
2. Drawings shall show all equipment, ductwork, cable trays, fire protection system, coil pull spaces, chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room to verify space allocation and coordination of trades.
3. Provide plan and elevation views detailing installation.
4. Drawings shall include 1/4-inch scale drawing of each mechanical room. Drawing shall show coil pull spaces and coordination of all ductwork, all chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room. Provide plan and elevation views detailing installation

F. Electronic.
1. Provide a coordinated Navisworks model to the Engineer and Owner prior to proceeding with construction of MEP systems.

1.11 INTERFERENCE DRAWINGS

A. Interference drawings are drawings that indicate conflict between the various systems and other components of the building such as beams, columns, walls, etc. They shall be drawn to scale and shall include plans, elevations, sections and other details as required to clearly define the interference and to indicate the contractor's proposed solution.

B. They shall be submitted for approval whenever job measurements and an analysis of the drawings and specifications by the contractor indicate that the various systems cannot be installed without significant deviation from the intent of the contract. When such interference is encountered, work shall cease in the general area of the conflict until a resolution to the question has been approved.

1.12 GUARANTEE

A. Guarantee work for one year from the date of final acceptance of the project. During that period make good any faults or imperfections that may have arisen due to defects or omissions in materials or workmanship.

1.13 SERVICE

A. Perform service work required during the guarantee period including lubrication of bearings. Perform manufacturer's recommended monthly service and provide OwnerOwn with written report. Cleaning of air filters and pipe strainers is not included.

1.14 RESOLUTION OF CONFLICTS

A. Where conflicts may exist between and/or within the drawings and/or specifications, the higher quality, greater quantity, more restrictive, and/or more expensive requirement shall be required and shall be the basis of Contractor pricing. The Contractor shall notify the Engineer for resolution of the issue prior to executing the work in question.

1.15 QUALITY ASSURANCE

A. Refer to other Divisions of the Specifications for related Work.

B. All Work shall be performed by properly licensed technicians skilled in their respective trades. All materials, equipment and devices shall be installed in accordance with the recommendations of the manufacturer and in the best standard practice to bring about results of a first class condition.

C. Install, hang, support, etc. all MEP systems and equipment to satisfy all requirements of the applicable seismic zone using performance requirements and design criteria for project site as indicated by Engineer.

D. It is the intent, unless otherwise indicated, that all products and materials described and specified under this Division, shall be provided for a complete working system irrespective of use of the phrases "install", "furnish", "furnish and install", or "provide" as described above has been actually included.

E. The Contractor specifically and distinctly assumes all risk for damage or injury from whatever cause to property or person used or employed on or in connection with this Work and of all damages or injury to any person or property wherever located, resulting from an action or operation under the Contract in connection with the Work, and undertake the promise to defend the Owner against all claims on account of any such damage or injury.

F. The Contractor will be held responsible for the satisfactory execution and completion of the Work in accordance with the true intent of the Documents.

G. Provide without extra charge all incidental items required as part of the Work, even though it may not be specifically indicated. If the Contractor has reason for objecting to the use of any material, equipment, device or method of construction as indicated, he shall make report of such objections to the Owner's Representative, obtain proper approval and adjustment to the Contract, and shall proceed with the Work.

H. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code--Steel."

I. Steel Pipe Welding: Qualify processes and operators according to ASME BPVC-IX , "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

J. Electrical Characteristics for Mechanical Equipment: Equipment with electrical characteristics differing from those specified (including higher ratings) may be furnished provided it is submitted for evaluation (e.g., via an Alternate Manufacturer Evaluation Form) and approved in writing by the Engineer. In such cases, the Contractor shall modify all affected electrical services, circuit breakers, wiring, and conduit sizes as necessary to accommodate the alternate equipment. The Contractor shall bear all costs and responsibility for these modifications, with no additional cost to the Owner or liability to the Engineer. Any alternate equipment must still meet all specified minimum energy ratings or efficiency requirements.

K. Electric wiring
   1. All electric wiring shall be installed under Division 26, except for such equipment items as are prewired at their point of manufacture and so delivered to the project, and except for the following:
      a. Temperature Control Wiring and Power Wiring provided by controls contractor.
   2. Prepare and submit for review wiring diagrams for all equipment furnished under this Division. Show on these diagrams all power, interlock, and control circuits. When the Architect takes no exception to these drawings, they shall become installation drawings for the Contractor.
   3. All chilled water, condenser water piping, domestic cold and hot water piping, and wet fire protection system shall be heat traced when routed external to the building or in areas susceptible to freezing conditions.

L. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided on this project shall meet the requirements of the UL standard in every way, and shall be UL listed and labeled.

M. Products and materials shall be of the best quality customarily applied in quality commercial practice, and shall be by reputable manufacturers.

N. Each major component shall bear a nameplate giving the name and address of the manufacturer, and the catalog number or designation of the component.

O. Products and materials provided under this Division of the Specifications shall be essentially the standard item, unless otherwise noted, of the specified manufacturer, or where allowed, an alternate manufacturer.

P. Common Requirements for Independent Testing and Inspecting Agency Qualifications: Where this Section and other Sections of this Division call for an Independent Testing and Inspecting Agency (Testing Agency); the Testing Agency shall comply with the following requirements:
   1. Have the experience and capability to conduct the testing indicated,
   2. Be a nationally recognized testing laboratory (NRTL).
   3. Meet the following:
      a. Be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.
      b. Be regularly engaged in the testing of seismic support of HVAC equipment devices, installations, and systems.
      c. Use technicians who are regularly employed for testing services.

1.16 COMMISSIONING

A. Commissioning is part of the Work. Participate in meetings; complete prefunctional checklists; support functional testing; correct deficiencies; and submit documentation in accordance with Division 01.

1.17 DATE OF SUBSTANTIAL COMPLETION

A. The date of final acceptance shall be the date of substantial completion. Refer to Division One for additional requirements.

B. The date of final acceptance shall be documented in writing and signed by the Engineer, Owner and Contractor.

PART 2 PRODUCTS

2.01 GENERAL

A. All products shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. All equipment installed shall have local representation, local factory authorized service, and a local stock of repair parts. “Local” is defined as being within a 75 mile radius of the project site.

C. Responsibility for furnishing proper equipment and/or material and ensuring that equipment and/or material is installed as intended by the manufacturer rests entirely upon the Contractor. If needed, the Contractor shall request advice and supervisory assistance from the specific manufacturer’s representative during the installation.

D. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use and of the best quality. Materials and equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of work involved. All work shall be executed by workers skilled in their respective trades, and the installations shall provide a neat, precise appearance. Materials and/or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job site but shall be replaced with new materials and/or equipment.

E. Prevention of Rust: Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating.

2.02 MATERIALS AND EQUIPMENT

A. Furnish new and unused materials, pipes, pipe fittings, and equipment of domestic manufacture, where available. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

B. All pipe shall be shipped to the job site capped or otherwise sealed. This applies to all mechanical piping, fittings and components. All pipe shall be capped at the completion of fabrication and caps shall remain in place until pipe or fitting is connected to another pipe or fitting. Valves and components shall remain in their original packaging until they are installed in the piping system, Piping installed shall have open ends capped at the end of each workday. All Pipe, fittings and components shall be kept stored above finish floor or ground at all times. Any pipe, fittings or components found stored or resting on the finish floor or ground shall be considered scrap and shall be thrown away.

2.03 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are listed in individual Sections of Division 23. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

B. Manufacturers' names and catalog numbers specified under Sections of Division 23 are used to establish standards of design, performance, quality and serviceability and not to limit competition.

C. Equipment of similar design, equal to that specified, manufactured by a manufacturer named in the acceptable manufacturers' list will be acceptable on approval.

D. Substitutions:

1. Comply with provisions of Division 01 Section “Product Requirements”.
    a. If item of equipment or device offered as Substitution differs in dimension or configuration from that indicated in the Contract Documents, provide, as part of the substitution submittal, a drawing that shows that the equipment or devices proposed for Substitution can be installed in the space available without interfering with other trades or with access requirements for operations and maintenance in the completed project. Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.
    b. Where substitute equipment or devices requires different arrangement or connections from that indicated in the Contract Documents, install the equipment or devices to operate properly and in accordance with the requirements of the Contract Documents. Make incidental changes necessary in piping, ductwork or wiring which results from the inclusion of the substitute equipment or device without any additional cost to the Owner. Pay all additional costs incurred by other trades in connection with changes required by the inclusion of the substituted equipment or device in the Work.
2. If the Contractor desires to substitute a material or method as an equal to the specified item, he shall request permission from the Engineer, in writing, and shall include such literature, samples, etc., deemed necessary to establish the equal quality of his proposal.
3. The Owner's Representative reserves the right to call for samples of any item of product or material offered in substitution, together with a sample of the specific item when, in their opinion, the quality of the item and/or the appearance is involved, and it is deemed that an evaluation of the item may be better made by visual inspection.
4. If the Engineer deems it necessary in order to establish the equality between two or more products, he may require laboratory testing at the Contractor's expense in order to obtain information upon which to base a decision.
5. The Engineer will not give approval to material salesmen or subcontractors, and only in writing to the successful Contractor after the project has been awarded.
6. For each proposed substitution product, clearly show how the proposed product meets the requirements of the specifications, including performance.
7. No substitution will be considered unless it is presented in writing within that number of days after Notice to Proceed equal to 15 percent of the contract time.
8. Proposers of substitute products shall present samples, literature, test and performance data, record of other installations, names of Owners, architects, engineers, contractors and subcontractors as references, statement of current financial condition, and other technical information applicable to their products, to aid in determining the worth of the substitute product offered in relation to the material and work specified from the standpoint of the Owner's best interest. Substitute materials and products shall be used only if approved in writing by the Engineer in advance.
9. Approval of substitute materials offered shall not be a basis for contingent extra charges because of changes in other work or related work, such as roughing-in, electrical, structural or architectural, which may result from the substitution.
10. For any Contractor initiated substitutions or changes, Contractor shall be responsible for achieving results equal to or better than the product or design originally specified.
11. Basis of Design: Where a basis of design is indicated (i.e,, scheduled products), that product was used for the purposes of established space requirements, structural design for the building, utility connections, etc. If the contractor elects to furnish a product other than the basis of design product (either another named acceptable manufacturer or via substitution) the contractor is responsible for any construction or design costs associated with the non-basis of design product.
12. When any request for a substitution of a product or material is submitted and rejected, the item named in the Documents shall be furnished. Repetitive submittal of substitutions for the same item will not be considered.

2.04 NAMEPLATES

A. Each major equipment component shall have a manufacturer's nameplate with the manufacturer's address and model number securely attached to the equipment. All data on nameplates shall be legible at the time of Final Inspection.

B. For associated mechanical equipment without manufacturer nameplates which require nameplates (such as a control panels), nameplates shall be installed with stainless steel self-tapping screws or epoxy adhesive.

2.05 PIPE, TUBE, AND FITTINGS

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

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

C. All piping and tubing shall be of American manufacture unless otherwise indicated.

2.06 JOINING MATERIALS

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

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inchmaximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110/A21.10, rubber, flat face, 1/8 inchthick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813. For non-potable water applications use 50-50 tin/lead solder or 95-5 tin antimony, where allowed by code.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8M/A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. 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.

G. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.07 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180°F.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Eclipse, Inc.
      d. Epco Sales, Inc.
      e. Hart Industries, International, Inc.
      f. Viega LLC.
      g. Watts Industries, Inc.; Water Products Div.
      h. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. CTS Fabrications, USA
      d. Epco Sales, Inc.
      e. Viega LLC.
      f. Watts Industries, Inc.; Water Products Div.
      g. Zurn Industries Inc., Wilkins
      h. Or approved equal

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
      e. Or approved equal
   2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F
   1. Manufacturers:
      a. Calpico, Inc.
      b. Victaulic
      c. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225°F.
   1. Manufacturers:
      a. Perfection Corp.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Co., Inc.
      d. Victaulic Co. of America.
      e. Shure Flow

2.08 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
      e. Linkseal by Thunderline
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel. Include two for each sealing element.
   4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.09 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

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

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. For Cast-In-Place or core drill applications:
   1. Hilti
   2. Hold-Rite
   3. Pro-Set

2.10 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.11 GROUT

A. Description: ASTM C1107/C1107M, Grade B, non-shrink and non-metallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, non-gaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.12 NOISE AND VIBRATION

A. The heating, ventilating and air conditioning systems, and the component parts thereof, shall be guaranteed to operate without objectionable noise and vibration.

B. Provide foundations, supports and isolators as specified or indicated, properly adjusted to prevent transmission of vibration to the building structure, piping and other items.

C. Carefully fabricate ductwork and fittings with smooth interior finish to prevent turbulence and generation or regeneration of noise.

D. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate (without cost to

the Owner) that equipment performs within designated vibration limits indicated in the specifications, or as specified by manufacturer.

E. Seal all wall and partition penetrations (the penetration opening shall be one inch larger than penetrating member) by ducts and piping by stuffing the annular void with fiberglass insulation and then caulking over fully with a non hardening acoustical caulking applied to both sides of wall or partition.

2.13 AIR FILTERS AND PIPE STRAINERS

A. Immediately prior to final acceptance of project, inspect, clean and service hydronic system strainers and replace disposable type air filters.

B. Turn over to Owner additional sets of spare filters and other spare parts as specified.

2.14 FLAME SPREAD PROPERTIES OF MATERIALS

A. Materials and adhesives incorporated in this project shall conform NFPA 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90A. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50.

PART 3 - EXECUTION

3.01 PREPARATION

A. Cooperate with trades of adjacent, related or affected materials or operations, and with trades performing continuations of this Work in order to effect timely and accurate placing of Work and to coordinate, in proper and correct sequence, the Work of such trades.

B. The size of equipment indicated on the Drawings is based on the dimensions of a particular manufacturer. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine that the equipment proposed will fit in the space.

C. All mechanical equipment shall be installed in a location that permits access and operation of all associated controls, valves, etc, and allows for the maintenance of equipment and all other associated appurtenances.

3.02 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards, and conform to codes and ordinances of the authorities having jurisdiction.

B. Cooperation with Other Trades: Cooperation with trades of adjacent, related, or affected materials or operations and of trades performing continuations of work under subsequent contract is considered a part of this work in order to effect timely and accurate placement of work and to bring together in proper and correct sequence the work of such trades.

C. Workmanship: Work must be performed by workmen skilled in their trade.

D. Installation of all equipment and materials must be complete. Installation shall meet requirements of specifications and manufacturer’s recommendations.

E. Electrical Wiring of Motors and Equipment.

1. The Contractor shall note that the electrical design was based upon the mechanical equipment indicated on the mechanical construction documents and specifications. If Contractor proposes any mechanical equipment that requires changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.
2. The electrical trades shall provide all interconnecting wiring for the installation of all power. The electrical trades shall provide all disconnect switches as required for proper operation, as indicated on the Drawings or required by applicable code. All motor starters not specifically scheduled or specified as being provided by the equipment manufacturer under the scope of Division 23 shall be provided under the scope of Division 26.
3. The Mechanical Trades shall provide complete wiring diagrams indicating power wiring and interlock wiring. Diagrams shall be submitted to the Engineer for review within thirty (30) days after the submittals for equipment have been reviewed. Diagrams shall be

based on accepted equipment and shall be complete full phase and interlock control drawings, not a series of manufacturer's individual diagrams. After these diagrams have been reviewed by the Engineer, copies shall be transmitted to the Electrical Trades by the Contractor. They shall be followed in detail.

F. Equipment - Common Rerquirements
   1. Equipment called for on the plans and not listed herein shall be provided as though it were fully described herein.
   2. Equipment called for herein shall be completely provided, whether fully detailed or not on the plans, and/or scheduled.
   3. All equipment as indicated on the plans and as described herein shall be installed per manufacturer’s recommendations to allow for proper operation and maintenance of the equipment.
   4. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.
   5. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
   6. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
   7. Where any piece of equipment is too large for ingress through normal building openings, it shall be placed in its containing space before the enclosing structure is completed.
   8. Install equipment to allow right of way for piping installed at required slope.
   9. Provide prefabricated, factory insulated curbs for roof-mounted equipment, a minimum of 18 inches in height above the finished roof surface. Provide curb pitches to match roof slope where required. For healthcare projects, the curb height shall be a minumum of 18 inches in height above the finished roof surface and at a height to ensure the the outside air intake is a minimum of 36" above the finished roof surface.

G. Piping System - Common Requirements
   1. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
   2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
   3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
   4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
   5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   6. Install piping to permit valve servicing.
   7. Install piping at indicated slopes.
   8. Install piping free of sags and bends.
   9. Install fittings for changes in direction and branch connections.
   10. Install piping to allow application of insulation.
   11. Select system components with pressure rating equal to or greater than system operating pressure.
   12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
      a. New Piping:
         1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
         2) Insulated Piping: One-piece, stamped-steel type with spring clips.
         3) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw or spring clips.

4) Bare Piping in Equipment Rooms: One-piece, cast-brass type.
5) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

13. Sleeves are required for core-drilled holes and shall extend 1” above floor.
14. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
15. Install sleeves for pipes passing through concrete and masonry walls, and concrete floor and roof slabs.
    a. Penetration assemblies shall comply with U.L. Fire Resistance Directory requirements for wall penetrations.
    b. Cut sleeves to length for mounting flush with both surfaces.
        1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
    c. Install sleeves in new walls and slabs as new walls and slabs are constructed.
    d. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
        1) Steel Pipe Sleeves: For pipes smaller than NPS 6".
        2) Steel Sheet Sleeves: For pipes NPS 6" and larger, penetrating gypsum-board partitions.
        3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
            (a) Seal space outside of sleeve fittings with grout.
    e. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
    f. Pro-Set, Hold-rite – Hydra Flame, or Hilti Sleeves for Cast-In-Place concrete or core drill concrete applications is acceptable to be used.
16. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
17. Verify final equipment locations for roughing-in.
18. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

H. Piping Joint Construstion
1. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32. For non-potable water applications use 50-50 tin/lead solder or 95-5 tin antimony, where allowed by code.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8M/A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

7. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Copper Press Joints
10. Copper, Steel and Galvanized Grooved Joints.

I. Piping Connections
1. Make connections according to the following, unless otherwise indicated:
a. Install unions, in piping NPS 2" and smaller, adjacent to each valve and at final connection to each piece of equipment.
b. Install flanges, in piping NPS 2-1/2" and larger, adjacent to flanged valves and at final connection to each piece of equipment.
c. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.03 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected via reviewed submittals.

B. Refer to equipment specifications in Divisions 2 through 48 for additional rough-in requirements.

3.04 INSTALLATION INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspecting authority.

B. The Contractor shall coordinate and obtain all required inspections and certifications in a timely manner. Submit documentation of approvals to the Engineer prior to final acceptance.

C. Upon final completion of the work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Engineer for transmission to the Owner.

3.05 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER, ARCHITECT AND ENGINEER

A. The Owner will cooperate with the Contractor, however, the following provisions must be observed:
1. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Sub-Contractors and the Engineer to discuss Contractor's employee parking space, access, storage of equipment or materials, and use of the Owner's facilities or utilities. The Owner's decisions regarding such matters shall be final.
2. During the construction of this project, normal facility activities will continue in existing buildings until renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems shall be maintained in service within the occupied spaces of the existing building.
3. Contractor shall not start-up any of the HVAC equipment unless the Owner and Engineer are signed off.
4. Start-up for major HVAC equipment such as chillers, cooling towers, variable frequency drives and hot water boilers shall be performed by a factory technician. The start-up shall include a written report signed off by Contractor, Engineer and Owner.

3.06 DEMOLITION AND RELOCATION

A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the Drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination or otherwise disposed of as directed by the Owner. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion, and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractorr shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.

C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner at no additional cost to the Owner.

D. In the preparation of these documents every effort has been made to show the approximate locations of, and connections to, the existing piping, duct, equipment and other apparatus related to this phase of the Work. However, this Contractor shall be responsible for verifying all of the above information. This Contractor shall visit the existing site to inspect the facilities and related areas. This Contractor shall inspect and verify all details and requirements of all the Contract Documents, prior to the submission of a proposal. All discrepancies between the Contract Documents and actual job-site conditions shall be resolved by the Contractor, who shall produce drawings that shall be submitted to the Engineer for review. All labor and materials required to perform the work described shall be a part of this Contract.

E. All equipment and/or systems noted on the Drawings "To Remain" shall be inspected and tested on site to certify its working condition. A written report on the condition of all equipment to remain, including a copy of the test results and recommended remedial actions and costs shall be made by this Contractor to the Engineer for review.

F. All equipment and/or systems noted on the Drawings "To Be Removed" shall be removed including, associated pipe and duct, pipe and duct hangers and/or line supports. Where duct or pipe is to be capped for future or end of line use, it shall be properly tagged with its function or service appropriately identified. Where existing equipment is to be removed or relocated and has an electric motor or connection, the Electrical Contractor shall disconnect motor or connection, remove wiring to a safe point and this Contractor shall remove or relocate motor or connection along with the equipment.

G. During construction and remodeling, portions of the Project shall remain in service. Construction equipment, material, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building. None of the construction work shall interfere with the proper operation of the existing facility; or be so conducted as to cause harm or danger to persons on the premises. All fire exits, stairs or corridors required for proper access, circulation or exit shall remain clear of equipment, materials or debris. The General Contractor shall maintain barricades, other separations in corridors and other spaces where work is conducted.

H. Certain work during the demolition and construction phases may require overtime or night time shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner at least seventy-two (72) hours in advance in writing.

I. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.

J. Equipment, piping or other potential hazards to the occupants of the building shall not be left overnight outside of the designated working or construction area.

K. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch or replace as required any damage that occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction and to keep construction disrupted areas to a minimum. Coordinate with the Owner and other trades in scheduling and performance of the work.

L. Include in the contract price all rerouting of existing pipe, duct, etc., and the reconnecting of the existing equipment as necessitated by field conditions to allow the installation of the new systems regardless of whether or not such rerouting, reconnecting or relocating is shown on the Drawings. Furnish all temporary pipe, duct, controls, etc., as required to maintain heating, cooling, and ventilation services for the existing areas with a minimum of interruption.

M. All existing pipe, duct, materials, equipment, controls and appurtenances not included in the remodel or alteration areas are to remain in place.

N. Pipe, duct, equipment and controls serving mechanical and other Owner's equipment, etc., which is to remain but is served by pipe, duct, equipment and controls that are disturbed by the remodeling work, shall be reconnected in such a manner as to leave this equipment in proper operating condition.

O. No portion of the fire protection systems shall be turned off, modified or changed in any way without the express knowledge and written permission of the Owner’s representative in order to protect systems that shall remain in service.

P. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and operating system in cooperation with other trades with a minimum of disruption or downtime.

Q. Refer to Architectural Demolition and/or Alteration plans for actual location of walls, ceilings, etc., being removed and/or remodeled.

3.07 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   1. Construct concrete bases of dimensions indicated, but not less than 6 inches larger in both directions than supported unit.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.
   6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

B. Provide concrete housekeeping pads and equipment bases for the following: outdoor equipment on grade, indoor floor mounted equipment in mechanical rooms and penthouse equipment rooms.

3.08 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

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

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.09 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.10 SPACE REQUIREMENTS

A. Consider space limitations imposed by contiguous work, including clearances required for service, in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.

B. The following space allocation and coordination shall be followed, unless otherwise indicated on the construction drawings:
   1. Gravity-fed plumbing and roof drain line shall take priority over all other systems.
   2. Light fixtures and cable tray arrangements shall take priority in spatial layout. In areas with ceilings, other systems shall be routed above the light fixtures, and offset from above cable tray allowing for access and maintenance clearance.
   3. Install HVAC ductwork as close to the bottom of structural framing as possible while allowing clearance for installation of insulation wrap. Install ductwork to be accessible from the ceiling plane.
   4. Install HVAC chilled/hot water piping in the plane directly below HVAC ductwork unless indicated otherwise on drawings.
   5. Install fire sprinkler piping in the plane directly beneath the HVAC chilled/hot water piping. Do not install sprinkler piping directly below equipment requiring maintenance.
   6. Install domestic hot and cold water in the plane directly above the light fixtures.
   7. Refer to Division 26 for electrical and control wiring requirements.
   8. Install piping to permit removal of coils at air handling units and to permit access to all terminal unit components.

3.11 OBSTRUCTIONS

A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.

B. Before any cutting or trenching operations are begun, verify with Owner's Representative, utility companies and other interested parties that all available information has been provided. Verify locations given.

C. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.

D. Assume total responsibility for and repair any damage to existing utilities or construction.

3.12 OPENINGS

A. Framed, cast or masonry openings for ductwork, equipment and piping are specified under other divisions. However, drawings and layout work for exact size and location of all such openings are included under this division.

3.13 DELIVERY, STORAGE AND HANDLING

A. Adequately protect work, equipment, fixtures and materials from damage during storing, installation, start-up and testing.

B. Cover all equipment stored exposed to elements with waterproof tarps, provide adequate ventilation.

C. At work completion, all work must be clean and in like new condition.

D. Storage of all mechanical equipment, piping materials and ductwork shall be in strict accordance with manufacturers written installation instructions.

E. Rotate air handler fans and pump shafts on routine basis.

F. Provide factory installed pipe caps for all pipes to be installed on the project.

G. Provide covers over all openings in ductwork stored or installed on the project.

H. Energize motor heaters with temporary power as soon as the motor is received on site.

I. Air Handling Units shall not be used as storage containers

3.14 LUBRICATION AND OIL

A. Provide a complete charge of correct lubricant and/or oil for each item of equipment requiring lubrication.

3.15 PAINTING

A. Paint exposed equipment and materials per the contract documents and the requirements of Division 09 – Finishes.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.16 CUTTING AND PATCHING

A. General: Cut and patch walls, floors, etc., resulting from work or by failure to provide proper openings or recesses in new construction.

B. Protection of Installed Work:
   1. During cutting and patching operations, protect adjacent installations.
   2. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

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

D. Methods of cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Engineer.
   1. Do not use impact-type equipment except where specifically acceptable to the Engineer.
   2. Core drill openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., to exact size.

E. Restoration: Restore all openings to "as-new" condition under the appropriate Specification Section for the materials involved, and shall match remaining surrounding materials and/or finishes.

F. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner approved by the Engineer.

G. Plaster: All mechanical work in areas containing plaster shall be completed prior to the application of the finish plaster coat. Cutting of finish plaster coat will not be permitted.

H. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

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

3.17 TESTS

A. When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, Contractor may do so, provided that Contractor properly supervises the operation, and has the Owner's written permission to do so. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner, or date of Substantial Completion, whichever occurs first.

B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, properly adjust, and complete all deficiency list items before final acceptance by the Owner. The date of acceptance and performance certification will be the same date.

C. Before the Work is accepted, an authorized representative of the manufacturer of the installed materials and/or equipment shall personally inspect the installation and operation of manufacturer's materials and/or equipment to determine that materials and/or equipment are properly installed and in proper operating order. The qualifications of the manufacturer's representative shall be appropriate to the technical requirements of the installation. The qualifications of the manufacturer's representative shall be submitted to the Owner for approval. The decision of the Owner concerning the appropriateness of the manufacturer's representative shall be final. Testing and checking shall be accomplished during the course of the Work where required by Work being concealed, and at the completion of the Work. In addition, the Contractor shall submit to the Engineer a signed statement from each manufacturer's representative certifying as follows: **"I certify that the materials and/or equipment listed below have been personally inspected by the undersigned authorized manufacturer's representative and is properly installed and operating in accordance with the manufacturer's recommendations."**

D. Check inspections shall include piping, equipment, insulation, controls, wiring and such other items and systems components hereinafter specified or specifically designated by the Engineer.

E. The Contractor shall execute, at no additional cost to the Owner, any tests required by the Contractor or the National Fire Protection Association, ASTM, etc. Standards listed. The Contractor shall provide all equipment, materials and labor for making such tests. The Owner will pay reasonable amounts of fuel and electrical energy costs for system tests. Fuel and electrical energy costs for system adjustment and tests, which follow Substantial Completion by the Owner, will be borne by the Owner.

F. Notify the Owner's Project Manager and the Engineer in writing at least seven (7) working days prior to each test and prior to other Specification requirements requiring Owner and Engineer to observe and/or approve tests.

G. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel performing, observing and inspecting, description of the test and extent of system tested, test conditions, test results, specified results an other pertinent data. Data shall be delivered to the Engineer as specified under "Requirements for Final Acceptance." The Contractor or Contractor's authorized job superintendent shall legibly sign all Test Log entries. For pipe testing requirements see the specific piping specification or standard.

3.18 OPERATING TESTS

A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation witnessed by Owner's Representative.

B. Prove operations of control systems and all safeties, freezestats and alarms.

C. Make adjustments as required to ensure proper functioning of all systems.

D. Special tests on individual systems are specified under individual Sections.

E. Functional Performance Testing is part of the Commissioning Process. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Agent. Refer to Division 01 Section "General Commissioning," for functional performance testing and commissioning requirements.

3.19 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Furnish copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings in accordance with Division 01 Section "Closeout Submittals." Detailed requirements for these items are as follows:
   1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies to the equipment and information which does not apply. Data shall include as a minimum the following items:
      a. Recommended procedures and frequencies for preventive maintenance; inspection, adjustment, lubrication, cleaning, etc.
      b. Special tools and equipment required for testing and maintenance.
      c. Parts lists reflecting the true manufacturer's name, part number and nomenclature.
      d. Recommended spares by part number and nomenclature and spare stocking levels.
      e. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
      f. Troubleshooting, checkout, repair and replacement procurement procedures.
      g. Operating instructions including start up and shutdown procedures.
      h. Safety considerations including load limits, speed, temperature and pressure.
   2. Provide O&M manuals for all HVAC equipment.

3.20 RECORD DOCUMENTS

A. Prepare Record Documents in accordance with the requirements of Division 00 and Division 01, in addition to the requirements specified in Division 23.

B. The Contractor shall maintain a separate set of clearly and legibly marked Record Drawings on the job site to record all changes and modifications, including, but not limited to the following: work details, alterations to meet site conditions, and changes made by "Change Order" notices. Mark the drawings with colored pencil(s). These shall be available for review by the Owner and Engineer during the entire construction stage.

C. The Record Drawings shall be updated concurrently as construction progresses, and in no case less frequently than a daily basis. They shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents. All dimensions shall include at least two dimensions to permanent structure points.

D. Record Drawings shall indicate, at a minimum, the following installed conditions:
   1. Duct mains and branches, size and location, for both exterior and interior; locations of dampers, fire dampers, duct access panels, and other control devices; filters, fuel fired heaters, fan coils, condensing units, and roof-top A/C units requiring periodic maintenance or repair.
   2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e.,

traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.

3. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
4. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
5. Contract Modifications, actual equipment and materials installed.

E. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.

F. If the Contractor does not keep an accurate set of Record Drawings, the pay request may be altered or delayed at the request of the Engineer. Delivery of Record Documents is a condition of final acceptance. Record Drawings shall be furnished in addition to Shop Drawings.

G. The Contractor shall submit an electronic copy of the record documents in PDF format and one (1) full size set of Record Drawing prints to the Engineer for review prior to scheduling the final inspection at the completion of the work. The drawings shall have the name(s) and seal(s) of the Engineer(s) removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS
DATE:
(NAME OF GENERAL CONTRACTOR)
BY: _____
(SIGNATURE)
(NAME OF SUBCONTRACTOR)
BY: _____
(SIGNATURE)

3.21 TRAINING

A. Upon completion of work, and at time designated by the Owner's Representative, provide services of a competent representative of the Manufacturer/Contractor to instruct the Owner's Representative and up to 8 members of the Owner’s staff in the operation and maintenance of the entire system. Record training sessions on DVDs for instructing future technicians.

B. Provide training for the following pieces of equipment:

Items:	HRs of Training Pre-Substantial Completion	HRs of Training at 6 months from Substantial Completion	HRs of Training at 11 months from Substantial Completion	Video Taping Required
Pumps	4			X
DDC Controls	16	8	8	X
VFDs	4	4		X
Air Handling Units	4			X
Chillers	8	8	8	X
Cooling Towers	4			X
Boilers	8	4		X
Refrigerant Monitors	4			X
Fans	4			
Water Treatment equipment	4	4	4	X

C. All training sessions shall be scheduled in coordination with the Owner’s Representative 14 days in advance, attendance taken, and sign-in sheet and training materials included in the O&M manuals.

D. Refer to Division 01 Section "General Commissioning," for additional contractor training requirements.

END OF SECTION 23 0010

SECTION 23 0300
MECHANICAL DEMOLITION FOR RENOVATIONS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Mechanical demolition.

B. The Drawings do not show all demolition work required. The Contractor shall make himself familiar with the required scope of work to accomplish the work required by these documents. All demolition work implied or required shall be included in the scope of this contract.

C. Utility service outages required by the new installation will be permitted but only at a time approved by the Owner. The Contractor shall allow the Owner (2) two weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.

1.02 RELATED SECTIONS

A. Divison 02 Section "Demolition and Structure Moving."

1.03 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER

A. The Owner will cooperate with the Contractor; however, the following provisions must be observed:

1. During the construction of this project, normal facility activities will continue in existing buildings until new buildings or renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems shall be maintained in service within the occupied spaces of the existing building.
2. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Subcontractors and Sub-subcontractors, and the Engineer to discuss Contractor's employee parking space, access, storage of equipment or materials, and use of the Owner's facilities or utilities. The Owner's decisions regarding such matters shall be final.

1.04 DEMOLITION AND WORK WITHIN EXISTING BUILDINGS

A. In the preparation of these documents every effort has been made to show the approximate locations of, and connections to the existing piping, duct, equipment and other apparatus related to this phase of the Work. However, this Contractor shall be responsible for verifying all of the above information. This Contractor shall visit the existing site to inspect the facilities and related areas. This Contractor shall inspect and verify all details and requirements of all the Contract Documents, prior to the submission of a proposal. All discrepancies between the Contract Documents and actual job-site conditions shall be resolved by the Contractor, who shall produce drawings which shall be submitted to the Engineer for review. All labor and materials required to perform the work described shall be a part of this Contract.

B. All equipment and/or systems noted on the Drawings "To Remain" shall be inspected and tested on site to certify its working condition. A written report on the condition of all equipment to remain, including a copy of the test results and recommended remedial actions and costs shall be made by this Contractor to the Engineer for review.

C. All equipment and/or systems noted on the Drawings "To Be Removed" should be removed including, associated pipe and duct, pipe and duct hangers and/or line supports. Where duct or pipe is to be capped for future or end of line use, it shall be properly tagged with its function or service appropriately identified. Where existing equipment is to be removed or relocated and has an electric motor or connection, the Electrical Contractor shall disconnect motor or connection, remove wiring to a safe point and this Contractor shall remove or relocate motor or connection along with the equipment.

D. During construction and remodeling, portions of the Project shall remain in service. Construction equipment, material, tools, extension cords, etc., shall be arranged so as to

present minimum hazard or interruption to the occupants of the building. None of the construction work shall interfere with the proper operation of the existing facility; or be so conducted as to cause harm or danger to persons on the premises. All fire exits, stairs or corridors required for proper access, circulation or exit shall remain clear of equipment, materials or debris. The General Contractor shall maintain barricades, other separations in corridors and other spaces where work is conducted.

E. Certain work during the demolition and construction phases may require overtime or night time shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner at least seventy-two (72) hours in advance in writing.

F. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.

G. Equipment, piping or other potential hazards to the occupants of the building shall not be left overnight outside of the designated working or construction area.

H. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch or replace as required any damage which occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction and to keep construction disrupted areas to a minimum. Coordinate with the Owner and other trades in scheduling and performance of the work.

I. Include in the contract price all rerouting of existing pipe, duct, etc., and the reconnecting of the existing equipment as necessitated by field conditions to allow the installation of the new systems regardless of whether or not such rerouting, reconnecting or relocating is shown on the drawings. Furnish all temporary pipe, duct, controls, etc., as required to maintain heating, cooling, and ventilation services for the existing areas with a minimum of interruption.

J. All existing pipe, duct, materials, equipment, controls and appurtenances not included in the remodel or alteration areas are to remain in place.

K. Pipe, duct, equipment and controls serving mechanical and other Owner's equipment, etc., which is to remain but which is served by pipe, duct, equipment and controls that are disturbed by the remodeling work, shall be reconnected in such a manner as to leave this equipment in proper operating condition.

L. No portion of the fire protection systems shall be turned off, modified or changed in any way without the express knowledge and written permission of the Owner's representative in order to protect systems that shall remain in service.

M. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and operating system in cooperation with other trades with a minimum of disruption or downtime.

N. Refer to Architectural Demolition and/or Alteration plans for actual location of walls, ceilings, etc., being removed and/or remodeled.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Field verify measurements, and piping arrangements are as shown on Drawings.

B. Verify that abandoned piping and equipment serve only abandoned facilities.

C. Demolition Drawings are based on casual field observation and existing Record Documents. Report discrepancies to Architect and Engineer before disturbing existing installation.

D. Beginning of demolition means that the contractor accepts existing conditions.

3.02 PREPARATION

A. Disconnect mechanical systems in walls, floors, and ceilings scheduled for removal.

B. Coordinate utility service outages with Utility Company.

C. Provide temporary connections, if required, to maintain existing systems in service during construction. When work must be performed on energized equipment, use personnel experienced in such operations.

D. Existing Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner and local fire service at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.03 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

A. Demolish and extend existing mechanical work under provisions of Division 02 and this Section.

B. Remove, relocate, and extend existing systems to accommodate new construction.

C. Remove abandoned piping to source of supply.

D. Remove exposed abandoned piping systems, including abandoned systems above accessible ceiling finishes. Cut systems flush with walls and floors, and patch surfaces.

E. Repair adjacent construction and finishes damaged during demolition and extension work.

F. Maintain access to existing systems which remain active. Modify installation or provide access doors as appropriate.

G. Extend existing systems using materials and methods compatible with existing systems, or as specified.

3.04 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

3.05 INSTALLATION

A. Install relocated materials and equipment under the provisions of Division 02.

3.06 REMOVAL OF MATERIALS

A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the Drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination as directed by the Owner. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operating condition. The Contractor may, at his discretion and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.

C. When items scheduled for relocation are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are

the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner, at no additional cost to the Owner.

D. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the Drawings, specified, or acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Owner. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities which must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

E. Certain work during the demolition and construction phases may require overtime or nighttime shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner's Representative at least 72 hours in advance in writing.

F. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch, or replace as required any damage which occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction. Cooperate with the Owner and other trades in scheduling and performance of the work.

G. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all electrical services for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.

H. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.

I. Where partitions, walls, floors, or ceilings of existing construction are being removed, all contractors shall remove and reinstall in locations approved by the Architect all devices required for the operation of the various systems installed in the existing construction.

END OF SECTION 23 0300

SECTION 23 0513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. 29 CFR 1910 - Occupational Safety and Health Standards; Current Edition.

B. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015 (Reaffirmed 2020).

C. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; 2017.

D. NECA 430 - Standard for Installing Medium-Voltage Switchgear; 2016.

E. NEMA MG 00001 - Motors and Generators; 2024.

F. NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment And Systems; 2025.

G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

H. UL 674 - Electrical Motors and Generators for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.

I. UL 1004 - Standard for Electric Motors; Current Edition, Including All Revisions.

1.02 SUMMARY

A. Section includes general requirements for 1-phase and 3-phase electric motors with NEMA frame machines sized through 200 horsepower and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation. Unless otherwise specified, provide motors meeting the basic requirements for general purpose alternating current motors, as defined in ANSI/NEMA MG 00001-1.05.

1.03 DEFINITIONS

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

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

C. Exposed to weather: Outside of a weather tight room or vestibule.

D. Inverter duty motor: Motor insulated for 1000 to 1 turndown

E. Inverter ready motor: Motor insulated for 20 to 1 turndown.

F. TEFC Motor: Totally Enclosed Fan Cooled Motor

G. ODP Motor: Open Drip Proof Motor

1.04 RELATED REQUIREMENTS

A. Division 26 Section - "Wiring Connections:" Electrical characteristics and wiring connections.

B. Division 26 Section - "Enclosed Controllers."

1.05 SUBMITTALS

A. See Division 01 Section "Administrative Requirements for submittal procedures."

B. Provide the following information for each motor:
   1. Manufacturer.
   2. Rated full load horsepower.
   3. Rated volts.
   4. Number of phases.
   5. Frequency in hertz.
   6. Full load amperes (FLA).

7. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
8. Nominal speed at full load (rpm).
9. Service factor.
10. NEMA design letter.
11. NEMA machine type (ODP, WP-I, TEFC, etc).
12. Motor space heater voltage, wattage and number of wires (where applicable).
13. Provide details on shaft grounding system used on all motors controlled by or connected to a Variable Speed Drive.

C. For motors 3/4 horsepower and larger, include the following additional information:
1. NEMA frame size.
2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance with the intent of paragraph 2.5C.
3. Maximum ambient temperature for which motor is designed.
4. Time rating.
5. Bearing type.
6. Efficiency at full load.

D. For motors 20 horsepower and larger, include the following additional information:
1. No load amperes.
2. Efficiency at 1/2 and 3/4 load.
3. Power factor at no load, 1/2, 3/4 and full load.
4. Full load amperes.
5. Maximum guaranteed slip at full load.

E. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

F. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around field-installed motors. Show motor layout, mechanical power transfer link, driven load, and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

G. Qualification Data: For testing agency.

H. Source quality-control test reports.

I. Field quality-control test reports.

J. Operation and Maintenance Data:
1. For field-installed motors to include in emergency, operation, and maintenance manuals.
2. Include instructions for safe operating procedures.
3. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.06 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 field-installed motors through one source from a single manufacturer.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

D. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

E. 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.

F. Comply with NFPA 70.

G. Provide certificate of compliance from Authority Having Jurisdiction indicating approval of high efficiency motors.

1.07 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
   2. Motor controllers (magnetic, multispeed, & reduced voltage).
   3. Torque, speed, and horsepower requirements of the load.
   4. Ratings and characteristics of supply circuit and required control sequence.
   5. Ambient and environmental conditions of installation location.

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

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.09 WARRANTY

A. See Division 01 Section "Closeout Submittals for additional warranty requirements."

B. Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements for integral horsepower motors, provide products by one of the following:
   1. General Electric.
   2. Baldor/Reliance.
   3. Toshiba
   4. TECO Westinghouse.

2.02 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 00001 unless otherwise indicated.

2.03 MOTOR CHARACTERISTICS

A. Speed and Size:
   1. Speed and approximate horsepower ratings are specified in the driven equipment specification Sections or are indicated on the Drawings.
      a. 1800 rpm (4 pole) and

b. 3600 rpm (2 pole) motors are acceptable

2. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity.
3. Size motors so as not to overload at any point throughout the normal operating range.
4. Provide motors designed and rated for variable frequency drive applications where required.

B. Voltage:
1. Single phase: 115 volts for 120-volt nominal system voltage and 277 volts (refer to mechanical schedules).
2. Three phase: 460 volts for 480-volt nominal system voltage.

C. Frequency: 60 hertz.

D. Service Factor: According to NEMA MG 00001-12.47 but not less than 1.15.

E. Acceleration Time: For integral horsepower motors, the calculated acceleration time of the combined motor and driven load shall not exceed 4 seconds at 90 percent of rated voltage.

F. Efficiency:
1. Provide single-speed NEMA Design B Premium efficiency induction motors having minimal full-load motor efficiency no less than those listed in the latest edition of NEMA MG 1 Section 12.60 (EFFICIENCY LEVEL OF PREMIUM EFFICIENCY ELECTRIC MOTORS). Motors and manufacturers shall be officially listed and labeled by the NEMA Premium program.
2. Base motor efficiencies on a statistically valid control procedure conforming to ANSI/IEEE 112-84, Test Method B (Dynamometer), using NEMA MG 00001).
3. For motors rated at a horsepower not listed in the NEMA guidelines the motors shall conform to the next higher nominal motor horsepower efficiency rating.

2.04 DESIGN TYPE

A. Motors Smaller than 1/6 Horsepower: Single-phase squirrel-cage induction motors with integral thermal protectors.

B. Motors 1/6 through 1/2 Horsepower: Single-phase NEMA Design Letter N, squirrel-cage induction motors with integral thermal protectors.

C. Motors Larger than 1/2 Horsepower: 3-phase, NEMA Design Letter B, squirrel-cage induction motors.

D. Motor Driven by Variable Frequency Drives (VFDs): Motors driven by VFDs shall be per NEMA MG1, part 31.

2.05 MOTOR INSULATION

A. Class: Use Class F insulation system meeting the requirements of NEMA MG Part 31 and made of non-hygroscopic materials for motors 10 HP and larger.

B. Use Class B Temperature Rise: NEMA MG 00001-12.41 for fractional horsepower motors and NEMA MG 00001-12.42 for integral horsepower motors.

C. VFD Motors: Inverter duty type and capable of withstanding repeated peaks of 1600 volts at 0.1 microsecond rise time. Comply with NEMA MG 00001 Part 31.

2.06 LEADS

A. Use not less than ASTM B 173, Class G, stranded copper conductors with insulation the same as or better than specified in the preceding Motor Insulation paragraph.

B. Provide permanent identification numbers on leads according to NEMA MG 00001-2.02.

C. Use crimp-on, solderless copper terminals on leads and place heat-shrink insulation sleeves or covers between leads and terminals.

2.07 ENCLOSURE

A. Indoors:

1. Open drip-proof (ODP).
2. Use steel frame for motors smaller than 3/4 horsepower and up to 1 HP, and cast-iron frame for motors over 1 horsepower.

B. Motors 1 HP and greater that are driven by variable frequency drives, provide motor with factory mounted shaft grounding ring. Shaft grounding device shall be accessible for inspection and replacement without disassembling the motor. Where factory mounting is not available, installation of shaft grounding shall be bolted in accordance with the manufacturers recommendations and shall not void the warranty. Conductive epoxy installation is not acceptable.

2.08 BEARINGS

A. Motors Smaller than 1/6 Horsepower: Motor manufacturer's standard bearing is acceptable.

B. Motors 1/6 Horsepower and Larger:
1. Antifriction:
   a. Supply motors with grease-lubricated antifriction ball bearings conservatively rated for long life under the total radial and thrust loads produced by the actual combination of motor-driven equipment.
   b. Provide each motor with suitable lubrication fittings and pressure relief devices suitable for in-service lubrication.
   c. Bearing calculated L10 life must be at least 250,000 hours for direct coupled applications.
2. Oil Lubricated: If the driven equipment Section specifies oil-lubricated bearings for motors, include a suitable sight gauge on each bearing with maximum and minimum levels clearly indicated.

2.09 HARDWARE

A. Use structural bolts, washers, nuts, pins, and similar items manufactured of high-strength steel. Use only hexagon-head bolts and hexagon nuts.

B. Use corrosion-resistant materials or protect hardware from corrosion by hot-dip galvanizing, chrome plating, or cadmium plating.

2.10 NAMEPLATES

A. Main Nameplate: Provide each motor with a stainless-steel nameplate meeting the requirements of NEMA MG 00001-10.38, and the National Electrical Code, Section 430-7. Identify energy-efficient motors in accordance with NEMA MG 00001 -12.54.2.

B. Bearings Nameplate: When bearings are oil lubricated, include oil type information on a suitable nameplate. Indicate bearing data if nonstandard.

C. Attachment: Attach the nameplates to the motor with stainless steel fastening pins or screws.

2.11 CONDUIT BOX

A. For each motor not supplied with a cord and plug, provide a conduit box suitably sized for the motor lead terminations, in accordance with the NECA 430-12. Include a grounding lug for motors 1/6 horsepower and larger. Supply a gasket suitable for the motor enclosure type and application.

2.12 PAINT

A. Manufacturer's standard shop paints for prime and finish coats are acceptable.

2.13 NOISE

A. Provide integral horsepower motors with overall sound power levels meeting the requirements of NEMA MG 00001-12.49.

2.14 STARTERS AND MOTOR CONTROLS

A. Provide starters for any motor not equipped with VFD.

B. All Motors that are automatically controlled and are equal to or over 1/2 horsepower require starters, no exceptions.

C. Provide each motor that does not require a starter, a manual starting switch with thermal overload protection with identifying nameplate, green pilot light and stainless steel cover plate equal to Westinghouse Type MS. Switches installed on finished walls shall be flush type.

D. Starter shall have overload protection on all phases. Provide NEMA 1B control voltage transformer, "on" green pilot light, and 1-normally open and 2-normally closed auxiliary contacts on each starter, unless otherwise noted.

E. On equipment that is NOT controlled by the EMS, provide a "HAND-OFF-AUTOMATIC" control switch. On equipment that is controlled by the EMS, the HOA switch shall be in the EMS field control panel, but the HOA switch shall operate independently if the EMS field control panel is inoperable.

F. Certain starters and motor controls for motors furnished under this Division are scheduled on the Drawings to be elements of motor control centers provided under Division 26. Except for those scheduled starters, provide a suitable starter for control of each motor furnished under this Division.

G. Each starter shall have a capacity rating within the required limits of the motor which it serves; it shall have overload elements selected to provide protection for the motor.

H. Where a combination starter and disconnect switch or starter and circuit breaker in a common enclosure is scheduled, provide auxiliary contacts on the switch or breaker as required to assure that, when the disconnecting means is open, there are no "live" contact points on the starter.

I. Where a schedule holding coil voltage differs from line voltage, install a transformer with secondary fusing in the starter enclosure.

J. Unless otherwise indicated, furnish starters mounted indoors with NEMA Type 1 enclosures; and furnish those exposed to the weather with NEMA Type 3R enclosures.

K. Where starters are exposed to the weather, the heater elements shall be of the ambient temperature-compensated, bimetallic type.

L. All motor starters and control devices shall be of one make and manufactured by one of the following: Allen-Bradley, Clark, Cutler-Hammer, General Electric, Square D, or Westinghouse.

M. Replace, belts, sheaves, dampers, valves, starters and heaters as necessary for actual start-up operating conditions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before motor installation.

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

3.02 INSTALLATION

A. Properly install and align motors in the locations as shown on Drawings. Use crimp-on, solderless copper terminals on the branch circuit conductors. For motors 20 horsepower and larger, use 5300 Series 3M motor lead splicing kit or approved equivalent.

B. The Nameplate must be in full view when motor and equipment are installed.

C. If a motor horsepower rating larger than indicated is offered as a substitute and is accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches, and other related items at no change in contract price.

D. Field-Installed Motor Installation

1. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.
2. Install motors on concrete bases complying with Division 3.
3. Comply with mounting and anchoring requirements specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.03 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

A. Prepare for acceptance tests.
   1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
   4. Test interlocks and control and safety features for proper operation.
   5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 00001 tolerances.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:
   1. Perform electrical tests and visual and mechanical inspections including optional tests and inspections stated in NETA ATS on factory- and field-installed motors. 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.

3.04 FIELD TESTING

A. Provide instruments, labor and personnel required to perform motor inspection and testing.

B. Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase identification, and cleanliness. Report abnormalities to Owner’s Representative before energizing.

C. Megger test all motors 20 horsepower and larger in accordance with IEEE Report No. 43, “Recommended Practices for testing Insulation Resistance of Rotating Machinery” to determine insulation resistance.

D. Measure full load current and full load voltage.

E. Complete and submit Motor Test Report forms to Owner’s Representative.

F. After installation has been thoroughly checked and found to be in proper condition with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.

3.05 FIELD-INSTALLED MOTOR DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain field-installed motors. Refer to Division 01 Section "Closeout Procedures."

END OF SECTION 23 0513

SECTION 23 0515
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; 2017.

B. IEEE 519 - IEEE Standard for Harmonic Control in Electric Power Systems; 2022.

C. IEEE C62.41.1 - IEEE Standard Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits; 2002 (Reaffirmed 2008).

D. IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits; 2002 (Corrigendum 2012).

E. NEMA IS 10033 - Adjustable Speed Drives; 2020 (Reapproved 2025).

F. NEMA MG 00001 - Motors and Generators; 2024.

G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

H. UL 508 - Industrial Control Equipment; Current Edition, Including All Revisions.

I. UL 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters - Electromechanical Contactors and Motor-starters; Current Edition, Including All Revisions.

1.02 WORK INCLUDED

A. Furnish complete the variable frequency drive (VFD) units as specified herein. All features described shall be included within the VFD enclosure.

1.03 SUBMITTALS

A. Submit complete product data, shop drawings, and wiring diagrams, including the rated input current of the VFD. Data shall clearly indicate the current distortion produced by the VFD (submittal will not be approved prior to receiving this information). See paragraph 2.2E for requirements. Make submittals under the provisions of Section 23 00 00 and Division 01.

B. Product Data:
   1. Provide literature that indicates dimensions, weights, capacities, performance, gages and finishes of materials, and electrical characteristics and connection requirements.
   2. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring. Coordinate submittal with Direct Digital Controls supplier for interface with building control system.
   3. Ratings, including voltage and continuous current or horsepower.

C. Shop Drawings:
   1. Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
   2. Dimensioned drawings. Outline dimensional drawings of each size and type of variable frequency drive (VFD) proposed for use on this project. Include top and bottom views showing conduit entry and exit space, front and side elevations showing arrangement of devices, ventilation and cooling provisions, required clearances, and connection details. Include weight of each size and type of VFD proposed for use on this project, and mounting provisions.

D. Prior to Installation, Startup, and Testing:
   1. Submit manufacturer's written installation instructions.

2. Submit written procedures for field testing to be performed under Part 3 of this Section. Procedures shall include prerequisite and initial conditions, a list of required test instruments, and forms for documentation of test results. Testing forms shall include the range of acceptance values for each recorded parameter.
3. Operation and Maintenance Manuals. Submit O&M manuals in accordance with the requirements of Section 23 00 00 and Division 01. Include instructions for routine service, spare parts lists, and wiring diagrams.

E. Following Installation, Startup, and Testing. Submit the following information for record purposes in accordance with the requirements of Division 01, Submittals, prior to Owner acceptance.
1. Records. Final as-built drawings and information for items listed in this Section.
2. Certified factory production test reports, as specified in this Section.
3. Manufacturer's Field Start-up Report and Certification, as specified in this Section.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. UL Compliance:
1. Comply with UL 508,
2. Comply with UL 60947-4-1A for Motor Starters and Contactors.

C. IEEE Compliance:
1. Comply with IEEE 112-B, Test Procedure for Polyphase Induction Motors and Generators.
2. Comply with IEEE 519, Harmonic Control in Electrical Power Systems.
3. Comply with IEEE C62.41.1, Surge Voltages in Low-Voltage AC Power Circuits.

D. NEMA Compliance:
1. Comply with NEMA IS 10033.0, AC Adjustable Speed Drives.
2. Comply with NEMA MG 00001 for Motors.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. ABB.

B. Danfoss Graham.

C. Emerson

2.02 VFD UNIT

A. The variable frequency drive (VFD) motor controller shall convert 480 Volt, three-phase, 60 Hertz power to adjustable voltage (0 - 480V) and frequency (0 - 60 Hz.) three-phase, AC power for stepless motor speed control with a capability of 10:1 speed range.

B. The adjustable frequency controller shall be a space vector sine-coded Pulse-Width Modulated (PWM) or IGBT design. Modulation methods which incorporate "gear-changing" techniques are not acceptable.

C. The controller shall be suitable for use with any standard NEMA-B squirrel-cage induction motor(s) having a 1.15 Service Factor. At any time in the future, it shall be possible to substitute any standard motor (equivalent horsepower, voltage and RPM) in the field.

D. The variable frequency control shall operate satisfactorily when connected to a bus supplying other solid-state power conversion equipment which may be causing up to 10 percent total harmonic voltage distortion and commutation notches up to 36,500-volt microseconds, or when other VFD's are operated from the same bus.

E. Individual or simultaneous operation of VFD's shall not add more than 5 percent total harmonic voltage distortion and no more than 5 percent total harmonic current distortion (per IEEE 519) to the normal bus.

1. VFD manufacturer shall perform harmonic analysis based on the electrical one-line diagram.
2. The VFD manufacturer shall provide calculations specific to this installation, showing total harmonic voltage distortion is less than 5 percent.
3. Calculations shall include the following load criteria as indicated:
   a. All AHU motors at 90%
   b. All chillers at 66%
   c. All chilled water pumps at 66%
   d. All hot water pumps at 66%
4. Provide 12 pulse VFDs or 6 pulse VFDs with input line filters, sized and provided as required by the VFD manufacturer to ensure compliance with IEEE Standard 519. The resultant power factor with the addition of the filter shall be a minimum of 97%.
5. All VFD's shall include a minimum of 5 percent impedance reactors, no exceptions.

F. The VFD shall be provided with a harmonic filter that limits the current distortion to 5% or less. The resultant power factor with the addition of the filter shall be a minimum of 97%.
   1. Assume the following input power conditions:
      a. 98% power factor.
      b. Nominal voltage and frequency.

G. Any inverter that generates sufficient electrical line noise to interfere with operation of sensitive building equipment (including computers, printers, copiers, and imaging equipment) shall be field modified or replaced by the inverter supplier at no additional cost to the Owner.

H. The VFD shall be provided with a DDC System Interface. The DDC interface shall either be able to reside on the BAS system field level network or via MODBUS or BACNET. Contractor to verify the protocol required to interface with the DDC system prior to ordering the VFD.

I. The VFD shall include RFI/EMI filters to prevent high frequency noise interference from migrating back onto the power system and RFI interference with other equipment.

2.03 SCHEDULE

A. In general, capacities of equipment and electrical characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. One controller shall control the speed of one motor only. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the Owner.

B. Where rating of driven equipment furnished for this project is larger than scheduled or indicated on Drawings, provide variable speed drive suitable for driven equipment. Coordinate submittal data and unit selections with submittal data for driven equipment.

C. Provide VFDs as follows unless otherwise specified on the equipment schedule:
   1. For equipment that is redundant provide VFD without a constant speed bypass.
   2. For equipment that is not redundant provide VFD with a constant speed bypass.

D. Refer to the Drawing Schedules for sizes and ratings of the motors. Refer to other Sections for description of motors and their use.

2.04 BASIC DESCRIPTION

A. The controller shall produce an adjustable AC voltage/frequency output. It shall have an output voltage regulator to maintain correct output V/Hz. despite incoming voltage variations.

B. The controller shall have a continuous output current rating of 100 percent of motor nameplate current.

C. The VFD shall be of the Pulse-Width Modulated type and shall consist of a full-wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The Pulse Width Modulation strategy shall be of the space vector type implemented in a microprocessor which generates a sine-coded output voltage.

D. The inverter output shall be generated by Darlington power transistors which shall be controlled by six identical base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst-case RMS motor line current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation. The drive shall produce an output volts/Hertz pattern to produce adequate starting torque under all conditions and operate smoothly at all operating speeds on variable torque load.

2.05 FEATURES

A. The door of each power unit shall include a "POWER ON" light, a VFD fault light, a VFD run light, stop pushbutton, start pushbutton, a fault reset pushbutton, a "HAND-OFF-AUTOMATIC" selector switch, and a manual speed control potentiometer.

B. The VFD shall be software programmable to provide automatic restart after any individual trip condition resulting from overcurrent, overvoltage, undervoltage, or overtemperature. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of three attempts within a short time period.

C. A speed droop feature shall be included which reduces the speed of the drive on transient overloads. The drive is to return to set speed after transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive is to automatically compensate to prevent drive trip.

D. Automatic restart after drive trip or utility failure. Software selectable if not desired.

E. Speed profile: Individual adjustable settings for start, stop, entry, slope, and minimum and maximum speed points.

F. Process signal inverter: Software selectable to allow speed of drive to vary inversely with input signal.

G. A critical speed avoidance circuit will be included for selection of two critical speeds with a rejection band centered on that speed. The drive will ignore any speed signals requiring drive operation within the rejection band.

H. Proportional and integral setpoint process controller with menu driven selection and programming via door-mounted keypad.

I. Pick up a spinning load: The VFD shall be able to determine the motor speed and resume control of a motor which is spinning in either direction without tripping.

J. A door-mounted membrane keypad with integral 2-line, 24-character LCD display shall be furnished, capable of controlling the VFD and setting drive parameters, and shall include the following features:

K. The digital display must present all diagnostic message and parameter values in English engineering units when accessed, without the use of codes.

L. The digital keypad shall allow the operator to enter exact numerical settings in English engineering units. A plain English user menu shall be provided in software as a guide to parameter setting, (rather than codes). Drive parameters shall be factory set in EEPROM and resettable in the field through the keypad. Means of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred to new boards to reprogram spare boards.

M. Input circuit breaker, interlocked with the enclosure door, with through-the-door handle to provide positive disconnect of incoming AC power.

N. Constant speed bypass shall be provided to allow the motor to run across the line in the event of VFD shutdown. The transfer from the VFD to the line shall be accomplished manually by means of a selector switch. The bypass circuitry shall be enclosed separate from the VFD in a NEMA-1 cabinet.

O. The bypass cabinet shall include a door-interlocked input circuit breaker, a VFD output contactor, a full-voltage starting contactor (both contactors electrically interlocked), a thermal

overload relay to provide motor protection, a phase loss/under-voltage relay and a control power transformer. Mounted on the cabinet door shall be a two-line LCD display to indicate status of the bypass operation (i.e. VFD output contactor failure or bypass contactor failure, etc), VFD bypass selector switch, motor fault light, power "ON" light, motor "ON" VFD light, and motor "ON LINE" light. The VFD and the bypass shall both be provided with a DDC System Protocol interface. The bypass shall have four digital inputs for individual safety interlocks, damper end switch interface and provide voltage and current reading on all 3 phases as well as KW.

P. The drive shall be provided with two isolated form C alarm contacts to indicate VFD failure and run status to the DDC. In addition, the VFD shall have either a MODBUS or BACNET interface or be capable of residing on the DDC control system building level network.

Q. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

R. Normally the digital display shall simultaneously display:
   1. Speed demand in percent.
   2. Output current in amperes.
   3. Frequency in Hertz or RPM.
   4. Control Mode: Manual/Automatic.
   5. Total three-phase KW or output volts.

S. At the factory with compatible motor, provide at least three lock-out ranges (50 rpm maximum each), two of which can be used to correct any run test problems.

T. The VFD shall include a motor preheat function to prevent motor condensation during shut down periods.

U. The operator panel shall contain a clock with a battery backup. The clock provides the date and time for use in the fault logger and timer functions.

V. VFDs serving motors in fan array units shall be capable of being inverted to a speed in excess of 60 HZ to allow the control of direct drive Fan Wall Fans at a speed higher than the motor name plate speed. Speed shall be adjustable from 60 to 90 HZ if necessary. Final requirements to be coordinated with the Air Handler Unit Manufacturer.

2.06 SERVICE CONDITIONS

A. The controller shall be designed and constructed to operate within the following service conditions:
   1. Elevation: To 3300 Feet.
   2. Ambient Temperature Range: 0°C to 40°C.
   3. Atmosphere: Non-Condensing relative humidity to 95 percent.
   4. AC Line Voltage Variation: -30 percent to +10 percent.
   5. AC Line Frequency Variation: 3 Hertz.
   6. Output Frequency: Shall be able to operate at the rated motor horsepower up to 90 hertz without damage to the VFD.

2.07 ENCLOSURE

A. VFD components shall be factory mounted and wired on a dead front, grounded, NEMA-1 enclosure. NEMA 12 enclosure is acceptable in lieu of NEMA 1 enclosure. Enclosure shall be UL listed as a plenum rated VFD.

B. Finish: Apply a finish to enclosure cabinet, trim, and doors. Exterior and interior metal surfaces shall be cleaned and finished with electrostatically applied "powder coat" thermoset enamel baked over a rust-inhibiting phosphatized coating.

2.08 PROTECTIVE FEATURES AND CIRCUITS

A. The controller shall include the following protective features:

1. Single phase fault or 3-phase short circuit on VFD output terminals without damage to any power component.
2. Static instantaneous overcurrent and overvoltage trip with inverse overcurrent protection.
3. Static overspeed (over frequency) protection.
4. Line loss and undervoltage protection.
5. Power unit overtemperature protection.
6. Electronic motor overload protection.
7. Responsive action to motor winding temperature detectors or thermostatic switches.
8. Isolated operator controls.
9. Input line circuit breakers.
10. Be insensitive to incoming power phase sequence.
11. Have desaturation circuit to drive inverter section transistor base current to zero in event of controller fault.
12. Have DC bus discharge circuit for protection of operator and service personnel with an indicator lamp.
13. Input line noise suppression with line reactor.
14. Individual transistor overcurrent protection.

2.09 PARAMETER SETTINGS

A. The following system configuring settings shall be provided, without exception, field adjustable through the keypad/display unit or via the serial communication port only.

B. Motor Nameplate Data:
1. Motor frequency.
2. Number of poles.
3. Full load speed.
4. Motor volts.
5. Motor full load amps.
6. Motor KW.
7. Current minimum.
8. Current maximum.

C. VFD Limits:
1. Independent accel/decel rates.
2. 2.No load boost.
3. Vmin, Vmax, V/Hz.
4. Full load boost.
5. Overload trip curve select (Inverse or Constant).
6. Min/Max speed (frequency).
7. Auto reset for load or voltage trip select.
8. Slip compensation.
9. Catch-A Spinning-Load select.
10. Overload trip time set.

D. VFD Parameters:
1. Voltage loop gain.
2. Voltage loop stability.
3. Current loop stability.

E. Controller Adjustments:
1. PID control enable/disable.
2. Setpoint select.
3. Proportional band select.
4. Reset time select.
5. Rate time select.
6. Input signal scaling.

7. Input signal select (4-20mA/0-5 Volts).
8. Auto start functions: On/Off, Delay On/Off, Level Select On/Off.
9. Speed Profile: Entry, Exit, Point Select.
10. Min, Max Speed Select.
11. Inverse profile select (allows VFD speed to vary directly or inversely with input signal.)

2.10 DIAGNOSTIC FEATURES AND FAULT HANDLING

A. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions. Microprocessor systems must be products of the same manufacturer as the VFD (to assure single source responsibility, availability of service and access to spare parts).

B. A "FAULT LOG" shall record, store, display and print upon demand, the following for the 3 most recent events:
   1. VFD mode (Auto/Manual).
   2. Date and Time stamped for each fault
   3. Elapsed time (since previous fault).
   4. Type of fault.
   5. Reset mode (Auto/Manual).

C. A "HISTORIC LOG" shall record, store, display and print upon demand, the following control variables at 2.7 M/Sec. intervals for the 10 intervals immediately preceding a fault trip:
   1. VFD mode (manual/auto/inhibited/tripped/etc.).
   2. Speed demand.
   3. VFD output frequency.
   4. Drive inhibit (On/Off).
   5. Feedback (motor) Amps.
   6. VFD output volts.
   7. Type of fault:
      a. Inverter O/Temp.
      b. Over Voltage.
      c. Detection Error.
      d. Earth Leakage.
      e. Watchdog.
      f. PSU Power Fail.
      g. Manual Test.
      h. Out of Sat 1-6.
      i. Software Fault.
      j. Waveform Gen.
      k. Remote Watchdog.
      l. Thermistor.
      m. Sustained O/L.
      n. Bypass SCR Trip.

D. The fault log record shall be accessible via a RS485 serial link as well as line by line on the keypad display.

2.11 SYSTEM OPERATION

A. With the H-O-A switch in the "HAND" position, the drive shall be controlled by the manual speed potentiometer on the drive door.

B. With the H-O-A switch in "AUTOMATIC", the drive shall start remotely through the EMS and its speed shall be controlled by a 4-20mA, internally isolated signal from the local Powers Control Panel.

C. With the H-O-A switch in the "OFF" position, the run circuit will be open and the VFD will not operate.

D. The bypass switch shall provide the ability to service the control in bypass operation while not de-energizing the motor. It shall also allow for start/stop functions for the motor.

E. In case of an output ground fault or similar abnormal output condition, any VFD serving multiple units shall be able to automatically alternate its output to either the duty device or the standby device. The VFD shall be fully operational after an output ground fault condition.

2.12 QUALITY ASSURANCE AND FACTORY TESTS

A. The controller shall be subject to, but not limited to, the following quality assurance controls, procedures and tests:
   1. Power transistors, SCR's and diodes shall be tested to ensure correct function and highest reliability.
   2. Controller will be functionally tested with a motor to ensure that if the drive is started up according to the instruction manual provided, the unit will run properly.

B. Manufacture of VFD shall certify in shop drawings that VFD and equipment motors are compatible. Contractor shall provide VFD manufacturer complete motor data prior to submittal of shop drawings.

C. Manufacturer shall provide a 3-year warranty on parts and labor to owner for each VFD from date of acceptance by Owner.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under the provisions of Section 23 00 00.

B. Deliver products on site in factory fabricated protective containers, with factory installed shipping skids and lifting lugs. Inspect for damage.

C. Store in clean dry place, elevated above grade, and protected from weather, sunlight, dirt, moisture, corrosion, and construction traffic.

D. Handle carefully to avoid damage to components, enclosures, and finish. Use only lifting eyes and brackets provided for that purpose. Damaged products shall be rejected and shall not be installed on the project.

3.02 PREPARATION

A. Verify that surfaces are ready to receive Work.

B. Verify that field measurements are as shown on Shop Drawings and as instructed by manufacturer.

C. Verify that required utilities are available, in the proper location, and ready for use.

3.03 INSTALLATION

A. Install VFD in accordance with manufacturer’s published, printed instructions.

B. Mounting:
   1. Mount VFD on Unistrut frame anchored to 4-inch thick concrete pad or mount VFD on Unistrut that is anchored to wall if wall is within 5 feet of the equipment.
   2. Height: In general, mount units so that operating handle is approximately 60 inches above finished floor. Where grouped, align tops of units.
   3. Ensure that proper clearance is provided for enclosure as required per NEC Table 110.26(A)(1) for working clearance and dedicated equipment space. Ensure that proper clearance is provided for enclosure as required by manufacturer for proper cooling of VFD.

C. Coordinate with Division 26 to complete raceway, power wiring, and grounding in accordance with the requirements of the NEC and the recommendations of the VFD manufacturer as outlined in the installation manual.

D. Contractor shall verify the existence and proper installation and operation of auxiliary contact on all disconnects located between the load and the drive. Auxiliary contact shall command the

VFD to shut down as required to protect the VFD from damage. Any disconnects found lacking this function shall be corrected prior to the startup of the equipment. This shall be coordinated with division 26 to ensure provision of this feature for VFD's that are not in line of sight of the driven equipment.

E. Interface:
   1. Controls: Coordinate with the controls supplier to accomplish proper interface with the building automation system (BAS) direct digital controls (DDC). Refer to Division 23 for Direct Digital Controls.
   2. Fire Alarm: Coordinate with Division 28 and the fire alarm supplier to accomplish proper interface with the fire alarm system, as indicated on the Drawings. Refer to Division 28, Fire Alarm System.
   3. Shutdown: Coordinate with other divisions to accomplish proper interface for shutdown of VFD, as indicated on the Drawings and as specified in the construction documents.

F. Immediately prior to final acceptance, replace all air filters in VFD and clean inside of drives.

G. Manufacturer shall provide start-up services and training as follows:
   1. Start-up for Contractor to verify correct installation and proper operation, including power and controls wiring connections.
   2. Start-up for Controls Vendor to verify that VFD correctly responds to control command functions and provides alarm condition to control center.
   3. Provide a report for each VFD indicating start-up is complete and/or noting any deficiencies found with the installation. VFD report must be provided to engineer prior to substantial completion.
   4. Provide minimum two-day training, four (4) hours per day for up to twelve (12) people. The course shall be classroom instruction complete with visual aids, documentation, circuit diagrams and hands-on training. This course shall not be construed as a sales meeting, but rather as a school to familiarize the Owner with the care, troubleshooting, and servicing of the VFD.

END OF SECTION 23 0515

SECTION 23 0519
METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.

B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi; 2004 (Reaffirmed 2017).

C. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014 (Reapproved 2025).

D. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014 (Reapproved 2021).

E. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case; 2024.

F. AWWA C701 - Cold-Water Meters -- Turbine Type, for Customer Service; 2024.

G. AWWA M6 - Water Meters -- Selection, Installation, Testing, and Maintenance; 2012, with Addendum (2018).

H. ISO 20456 - Measurement of Fluid Flow in Closed Conduits; 2017.

I. ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories; 2017.

J. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

1.02 SUMMARY

A. Section Includes the following for hydronic piping:
   1. Flow Meters.
   2. Thermometers.
   3. Gauges.
   4. Pressure and Temperature Taps.
   5. Test Plugs.
   6. Thermowells.

1.03 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.04 SUBMITTALS

A. See Division 01 Section "Administrative Requirements for submittal procedures.

B. Product Data: For each type of product indicated, submit detailed shop drawings and manufacturer’s data, including:
   1. Measurement tolerances.
   2. Range.
   3. Accuracy.
   4. Device dimensions and connection sizes (include schedule indicating stem length versus pipe diameter).
   5. Scales.
   6. Materials of construction.
   7. Valves that will be used for isolating gauges.

C. Submit a schedule for each device to be installed, including:
   1. Location.
   2. Pressure or temperature range of device and fluid measured.
   3. Temperature or pressure of fluid.

4. Pipe size and bulb length of thermometers.
5. Type of valve used with the Pressure Gauge.

D. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

E. Operation and maintenance data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

F. Maintenance Materials: Furnish Owner with one wrench for every ten plug valves, in each size of square plug valve head.
1. See Division 01 Section "Product Requirements for additional provisions."

1.05 QUALITY ASSURANCE

A. Thermometers: Calibrate against standards traceable to the NIST and guaranteed accurate to plus or minus one scale division.

B. Pressure Gauges: ASME B40.100 Grade 2A accuracy 0.5 percent of scale range.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:
1. Flowmeters: Onicon, and Badger.
2. Pressure Gauges: Ashcroft, Dwyer, Trerice, Weiss, Weksler.
3. Pressure/Temperature Taps: Peterson Engineering Company, Sisco or Trerice.
4. Thermometers: Ashcroft, Dwyer, Marsh Instrument, Trerice, Weiss, Weksler.

2.02 INLINE MAGNETIC FLOW METERS

A. Basis of Design: Onicon Model FT-3200 Series Inline Electromagnetic Flow Meter.

B. Description: Provide an inline electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, transmitter, visual display, ANSI Class 150 or 300 mounting flanges, and calibration certificate.

C. Application:
1. Chilled Water.

D. Application Range: This contractor shall be responsible for selecting the flow meter options submitted based on the application. Flowmeter shall be constructed, calibrated and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions and fluid characteristics which include but are not limited to pressure, temperature, conductivity and viscosity.

E. Sensing Technology: Electromagnetic velocity-measuring element.

F. Design: Electromagnetic sensing element shall utilize a minimum of two 316L stainless steel electrodes to measure the average flow rate velocity.

G. Construction: Flowmeter shall consist of epoxy painted carbon steel outer body, 304 stainless steel flow tube and integral liner to be selected based on operating temperature and fluid. Individual calibration tag shall be attached indicating calibration and programming information.

H. Maximum Pressure Rating: 580 psig.

I. Maximum Temperature Rating: 266°F.

J. End Connections for NPS 1.0” and Larger: ANSI Class 150 Flange typical.

K. Flow Range: Flow-measuring element and transmitter shall cover operating range of equipment or system served.

L. Accuracy: Flowmeter shall provide calibrated outputs directly from the transmitter, throughout the operating range with the accuracy stated as follows:
1. Plus or minus 0.2% of rate from 1.6 to 33.0 ft/sec velocity.

2. Plus or minus 0.0033 ft/s at flow rates 1.6 ft/s

M. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard directly traceable to international standards in accordance with ISO 20456 and ISO/IEC 17025.

N. Transmitter Enclosure: Transmitter enclosure shall be cast aluminum, IP67 rated

O. Provide with Thermal Energy Meter.

P. Display: Menu driven via three (3) button programming keys and shall include 16 character, 8 line graphic LCD backlit display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.

Q. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

2.03 WATER PRESSURE GAUGES

A. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.
   1. Case: Liquid-filled type, polypropylene case, 4-1/2-inch diameter, solid front with blow-out back.
   2. Bourdon Tube: Bronze or 316 stainless steel with brass or stainless-steel socket.
   3. Movement: 300 series stainless steel rotary type with stainless steel bushings
   4. Dial: White face with black figure.
   5. Pointer: Red or black, micro adjustable.
   6. Window: Molded Acrylic.
   7. Ring: Fiberglass polypropylene.
   8. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
   9. Provide liquid filled gauges for all pressure gauges upstream and downstream of pumps.

B. Pressure-Gauge Fittings:
   1. Valves: NPS 1/4 brass or stainless-steel needle type.
   2. Siphons: NPS 1/4 coil of brass or stainless-steel tubing with threaded ends.
   3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.04 WATER PRESSURE AND TEMPERATURE TAPS:

A. Taps: Provide 1/2" solid brass fittings which will receive either a pressure or temperature probe, with valve core of Nordel and fitted with a color coded cap and gasket. P/T Taps shall be rated for 275°F. and 1000 psig. Provide long stem type for insulated pipe.

B. Instruments: Provide two each, No. 500 "Pete's Plug" pressure gauge adapters with four gauges and probes and four each 5" stem pocket thermometers: Two each, thermometers for chilled water, heating and domestic hot water systems, when applicable. Applicable meaning the system is being installed as part of the project. "Pete's Plugs" to match insulation thickness.

2.05 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Sisco Manufacturing Co.
   2. Trerice, H. O. Co.
   3. Watts Industries, Inc.; Water Products Div.
   4. Flow Design Inc.
   5. MG Piping Products Co, Inc.
   6. Peterson Equipment Co. Inc.
   7. Fairfax.
   8. Griswold.
   9. Nexus.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200°F.

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for air, water, oil, or gas service at 20 to 200°F shall be CR.
   2. Insert material for air or water service at minus 30 to plus 275°F shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
   1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be 0 to 200 psig.
   2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125°F.
   3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220°F.
   4. Carrying case shall have formed instrument padding.

2.06 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Brass or stainless steel with pressure and temperature ratings suitable for their application. Wells for insulated piping shall have a 2-1/2 inch lagging protrusion. Locate thermometer wells so the sensing bulb will give a true and correct reading. Install thermometer so as not to cause undue restriction in small piping. Where wells are located in pipelines 1-1/2 inch and smaller, provide a section of pipe of such diameter that the net area of the pipeline will not be reduced by the thermometer well.

2.07 FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brooks Instrument Div.; Emerson Electric Co.
   2. Dwyer Instruments, Inc.
   3. John C. Ernst Co.

B. Description: Instrument for installation in piping systems for visual verification of flow.

C. Construction: Bronze or stainless-steel body; with sight glass and plastic pelton-wheel indicator, and threaded or flanged ends.

D. Pressure Rating: 125 psig.

E. Temperature Rating: 200°F.

F. End Connections for NPS 2" and Smaller: Threaded.

G. End Connections for NPS 2-1/2" and Larger: Flanged.

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. Should valve is determined to be defective, replace with new valve.

3.02 INSTALLATIONS

A. Meters shall be installed per manufacture’s recommendations.

B. Install flowmeters in accessible locations in piping systems based on manufacturer’s recommendations regarding orientation and straight run requirements.

C. Provide sufficient clearance for complete removal of the flowmeters.

D. Install test plugs in tees in piping.

E. Locate test plugs adjacent thermometers and thermometer sockets or as detailed on the drawings. Place test plugs in an accessible location.

F. Mount meters on wall if accessible; if not, provide brackets to support meters.

3.03 GAUGE INSTALLATIONS

A. Provide pressure gauges in the following locations:
   1. Supply and return piping connections of coils (where shown on details).
   2. As shown on drawings and control schematics.

B. Install direct-mounting pressure gauges in piping tees with pressure gauge located on pipe at most readable position.

C. Install needle-valve and snubber fitting in piping for each pressure gauge for fluids (except steam).

D. Provide fittings as necessary to install pressure gauge in the vertical position.

E. 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.

3.04 GAUGE APPLICATIONS

A. Install dry-case-type pressure gauges for discharge of each pressure-reducing valve.

3.05 PRESSURE AND TEMPERATURE TAP INSTALLATIONS

A. Provide pressure and temperature taps at the following locations:
   1. Inlet and outlet of each coil connection.
   2. Inlet and outlet of each hydronic control valve
   3. Where shown in details on mechanical drawings.

3.06 COMMISSIONING

A. A.After installation, commission all meters according to manufacturer's written instructions.

3.07 ADJUSTING

A. Adjust faces of meters and gauges to proper angle for best visibility. Refer to manufacturers written instructions.

3.08 SCHEDULES

A. Pressure Gauges, Location and Scale Range:
   1. Pump Suction/Discharge, -30 - 100 psi.
   2. Control valves - inlets and outlets, 0 - 100 psi.

END OF SECTION 23 0519

SECTION 23 0523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. API STD 594 - Check Valves: Flanged, Lug, Wafer, and Butt-Welding; 2022.

B. ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).

C. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2020.

D. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard; 2025.

E. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves; 2022, with Errata (2023).

F. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.

G. ASME B16.24 - Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500; 2021.

H. ASME B16.34 - Valves — Flanged, Threaded, and Welding End; 2025.

I. ASME B31.1 - Power Piping; 2024.

J. ASME B31.9 - Building Services Piping; 2025.

K. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2025.

L. ASTM A48/A48M - Standard Specification for Gray Iron Castings; 2022.

M. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2023).

N. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service; 2021.

O. ASTM A351/A351M - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts; 2024, with Editorial Revision (2025).

P. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2022).

Q. ASTM A536 - Standard Specification for Ductile Iron Castings; 2024.

R. ASTM A582/A582M - Standard Specification for Free-Machining Stainless Steel Bars; 2022.

S. ASTM B32 - Standard Specification for Solder Metal; 2020.

T. ASTM B61 - Standard Specification for Steam or Valve Bronze Castings; 2015 (Reapproved 2021).

U. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings; 2017 (Reapproved 2025).

V. ASTM B813 - Standard Specification for Water Flushable Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2024.

W. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings; 2023.

X. AWWA C606 - Grooved and Shouldered Joints; 2022.

Y. MSS SP-45 - Drain and Bypass Connections; 2020.

Z. MSS SP-67 - Butterfly Valves; 2022.

AA. MSS SP-68 - High Pressure Butterfly Valves with Offset Design; 2021.

BB. MSS SP-70 - Gray Iron Gate Valves, Flanged and Threaded Ends; 2011.

CC. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends; 2018.

DD. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service; 2010a.

EE. MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends; 2011.

FF. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves; 2019.

GG. MSS SP-85 - Gray Iron Globe and Angle Valves, Flanged and Threaded Ends; 2011.

HH. MSS SP-108 - Resilient-Seated Cast Iron Eccentric Plug Valves; 2020.

II. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .

JJ. MSS SP-125 - Check Valves: Gray Iron and Ductile Iron, In-Line, Spring-Loaded, Center-Guided; 2018.

KK. NSF 61 - Drinking Water System Components - Health Effects; 2024.

1.02 SUMMARY

A. This Section includes requirements for furnishing and installing heating water, chilled water, and condensate piping valves and appurtenances, including fittings and strainers.

B. Related Sections:
   1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
   2. Section 23 0553, Identification for HVAC Piping and Equipment, for valve tags and schedules.

1.03 ABBREVIATIONS, ACRONYMS AND DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NPS: Nominal pipe size.

E. NRS: Nonrising stem.

F. OS&Y: Outside screw and yoke.

G. PTFE: Polytetrafluoroethylene.

H. RS: Rising stem.

I. TFE: Tetrafluoroethylene.

J. WOG: Water, oil, and gas.

1.04 SUBMITTALS

A. Product Data:
   1. Submit manufacturer’s product data showing compliance with requirements of Part 2. Clearly indicate piping, equipment, materials of construction, pressure rating and which options are to be provided.
   2. For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; weights; furnished specialties; and accessories.

B. Victaulic products shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series number.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect all piping, valves, fittings, etc. before installation in accordance with manufacturer’s written instructions.

B. Piping shall be sent from the factory with capped ends and shall be stored on supports off of the ground with ends covered to prevent nesting of insects, birds and other animals, or the accumulation of dirt and debris in and around the piping components.

1.06 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.
   1. Exceptions: Domestic hot- and cold-water piping valves unless referenced.

C. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

D. NSF Compliance: NSF 61 for valve materials for potable-water service.

E. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Provide only domestically manufactured piping and fittings.

B. Each valve style shall be the product of a single manufacturer (i.e. all butterfly valves shall be the same manufacturer, all ball valves shall be the same manufacturer, etc.).

C. Refer to HVAC valve schedule articles for applications of valves.

D. All valves shall be repackable under pressure, with the valve in the full open position. All gate valves, globe valves, and shutoff valves of every character shall have malleable iron hand wheels, except iron body valves 2-1/2" and larger which may have either malleable iron or ASTM A126 Class B, gray iron hand wheels.

E. Bronze Valves: NPS 2" and smaller with threaded ends, unless otherwise indicated.

F. Ferrous Valves: NPS 2-1/2" and larger with flanged ends, unless otherwise indicated.

G. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

H. Valve Sizes: Same as upstream piping, unless otherwise indicated.

I. Valve Actuator Types:
   1. Handlever: For quarter-turn valves NPS 6" and smaller except plug valves.
   2. Handwheel: For valves other than quarter-turn types.

J. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
   1. Ball Valves: Provide an insulated stem extension.
   2. Butterfly Valves: With extended neck.

K. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Solder Joint: With sockets according to ASME B16.18.
   3. Threaded: With threads according to ASME B1.20.1.

L. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

M. Valve Grooved Ends: AWWA C606.
   1. Solder Joint: With sockets according to ASME B16.18.
      a. Caution: Use solder with melting point below 840°F for angle, check, gate, and globe valves; below 421°F for ball valves.
   2. Threaded: With threads according to ASME B1.20.1.
   3. Press Joint.

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

2.02 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ball Valve: Apollo, Crane, Milwaukee, Nibco, or Watts .
   2. Butterfly Valves: Bray, Clow, Crane, Demco, DeZurik, Kitz, Milwaukee, Nibco, Pratt, or Stockham .
   3. Check Valves: Apco, Crane, Keckley, Kitz, Mission, Milwaukee, Mueller, Nibco, Powell, Southern California Valve, Stockham, Titan, or Weco .
   4. Gate abd Globe Valves: Crane, Milwaukee, Nibco, Powell, or Stockham.
   5. Strainers: Armstrong, Keckley, Mueller Spirax, or Watts .
   6. Where grooved piping is allowed, check valves, butterfly valves, ball valves and strainers as manufactured by Victaulic.

2.03 BALL VALVES

A. For pipe 2 inches in diameter and smaller, provide 600 psi WOG screwed, two-piece bronze or forged brass body, Teflon seat, full port, stainless steel stem and ball.

B. Where ball valves are used as balancing valves, provide valve with memory stop.

C. Where piping is insulated, ball valves shall be equipped with 2" extended, insulated handles of non-thermal conductive material. Also provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Memory stops, which are fully adjustable after insulation is applied, shall be included.

2.04 BUTTERFLY VALVES

A. General: MSS SP-68.

B. For pipe 2-1/2 through 12 inches in diameter, furnish 200-pound flanged or tapped lug type butterfly valve with ductile iron body, stainless steel stem, aluminum-bronze disc with EPDM liner. Provide lever-operated valves 5 inches and smaller. Furnish valves 6 inches and larger with totally enclosed worm gear operators. Provide valves with enclosed worm gear operators with chain wheel and chain on valves installed higher than 96 inches above floor. Use valves designed for drip-tight shutoff in dead end service against 200 psi.

C. Where balancing valve is shown, provide butterfly valve with position lock operator (memory stop) for valves 5 inches and smaller and worm gear operator with memory stop for valves 6 inches and larger.

D. All valves 24” and smaller shall be capable for use as isolation valve and recommended by manufacturer for bi-directional dead-end service at full rated pressure without the need for a

down-stream flange. Manufacturer to furnish letter of certification for bi-directional dead-end service.

2.05 CHECK VALVES

A. General: MSS SP-80.

B. For pipe 2 inches in diameter and smaller, furnish 150-pound (class 150) screwed, horizontal, swing check valve, all bronze construction, with screwed cap.

C. For pipe 2-1/2 to 10 inches in diameter, provide 125-pound (class 125), lugged style, drill and tapped, or retainerless wafer lug style, double door valve, with cast iron or cast steel body and aluminum bronze doors, Buna-N seat, and Type 316 stainless steel spring. At Contractor's option, a tapped double flange valve may be provided.

2.06 GLOBE VALVES

A. General: MSS SP-80.

B. For pipe 2 inches in diameter and smaller, provide 150-pound (class 150) screwed, rising stem, globe valve with bronze body, TFE disc, union bonnet.

C. For pipe 2-1/2 through 10 inches in diameter, provide 125-pound (class 125) flanged, OS&Y globe valve, with cast iron body, renewable bronze trim.

2.07 STRAINERS

A. For pipe 2 inches in diameter and smaller, use 125-pound (class 125) cast bonze screwed Y-type strainer with 12-mesh stainless steel screen. Provide full size blowoff ball valve where shown on drawings.

B. For pipe 2-1/2 inches and larger, provide 150-pound (class 150) cast steel or iron flanged Y-type strainer with 0.045-inch stainless steel screen through 4, and 1/8-inch stainless steel screen for 6 inches and larger. Provide full size blowoff ball valve where shown on drawings.

2.08 VALVES FOR GROOVED PIPING SYSTEMS

A. Check Valves
   1. For grooved piping systems, 2" through 12" Sizes Spring Assisted: Black enamel coated ductile iron body, ASTM A536, Grade 65-45-12, stainless steel non-slam tilting disc or elastomer encapsulated ductile iron disc suitable for intended service, stainless steel spring and shaft, welded-in nickel seat, 300 psi. Victaulic Series 716 or 779 (with venturi).

B. Butterfly Valves
   1. For grooved piping systems, 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be aluminum bronze with blowout proof 416 stainless steel stem. Disc shall be offset from the stem centerline to allow full 360-degree seating. Seat shall be pressure responsive EPDM. Valve bearings shall be TFE lined fiberglass, and stem seals shall be of the same grade elastomer as the valve seat. Valve shall be complete with ISO flange for actuation mounting. Valve operators shall be lever handle or gear operator, available with memory stop feature, locking device, chainwheel, or supplied bare. (Valve with EPDM seat is UL classified in accordance with ANSI/NSF 61.) Victaulic Vic®-300 MasterSeal™.

C. Ball Valves
   1. For Vic-Press Sch. 10S, 2 inches and smaller, CF8M stainless steel body, ball, and stem, PTFE seats, 304 stainless steel handle, nut, and stem washer, with Schedule 10S stainless steel type 316 Vic-Press™ and/or grooved ends. Rated for services to 400 psi. Victaulic Series P569. The valves shall have a blow-out proof stem and self-adjusting floating ball which provides uniform sealing. The full port design minimizes pressure drop for maximum flow efficiency. Valves shall be three-piece swing-out design to permit easy in-line maintenance.

D. Strainers

1. For grooved piping systems 2” through 18” sizes, 300 PSI Y-Type Strainer shall consist of ductile iron body, ASTM A536, Grade 65-45-12, Type 304 stainless steel perforated metal removable baskets with 1/16" diameter perforations 2"-3" strainer sizes, 1/8" diameter perforations 4"-12" strainer sizes, and 0.156” diameter perforations 14” -18” strainer sizes. Victaulic Style 732 and W732.

PART 3 - EXECUTION

3.01 STORAGE

A. Protect all piping, valves, fittings, etc. before installation in accordance with manufacturer’s written instructions. All piping shall be sent from the factory with capped ends and shall be stored on supports off of the ground with ends covered to prevent nesting of insects, birds and other animals, or the accumulation of dirt and debris in and around the piping components.

3.02 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.03 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

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

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

E. For shut-off service of hydronic systems, use
   1. Up to NPS 4": Ball type.
   2. NPS 5" and greater: Butterfly type.

F. Locate valves for easy access and provide separate support where necessary.

G. Provide clearance for access to valves, fittings and equipment for operation and maintenance.

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

I. Install valves in position to allow full stem movement and with operators and stems upright or horizontal.

J. Provide clamp lock lever handle for all valves, other than plug type, NPS 4" or smaller.

K. K.Provide hand wheel for all valves, other than plug type, NPS 6" and greater.

L. Install chainwheels on operators for butterfly gate and globe valves NPS 4" and larger and more than 84 inches above floor. Extend chains to 60 inches above finished floor elevation.

M. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

N. All piping shall be clean when it is installed.

O. Check Valves:
   1. Install lugged check valves between flat flange and full-face gasket.
   2. Install check valves a minimum three to four pipe diameters downstream of pump discharge or elbows to avoid flow turbulence.
   3. Install check valves for proper direction of flow and as follows:
      a. Edit check valve installation requirements to suit Project. Delete check valves not required.
      b. Swing Check Valves: In horizontal position with hinge pin level.
      c. Lift Check Valves: With stem upright and plumb.

3.04 ISOLATION VALVES

A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving equipment, and at other locations as indicated and required for isolation of piping or equipment.

B. At air handling units, where multicoil (stacked) arrangement is used, provide each supply and return line to and from each stacked coil section with a union, pressure gauge and thermometer well and a balancing valve (with memory stop) for balancing, and valves for isolation of each coil.

3.05 DRAIN VALVES AND VENTS

A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained.

B. Install 2-inch drain for 2-inch pipes and larger.

C. Install a line size drain valve for pipes smaller than 2 inches.

D. Provide hose adapter and cap on all drain lines.

E. Provide automatic vents with isolation valves or manual vents at locations as indicated on Drawings and all high points in piping systems.

3.06 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Mechanical General Provisions" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B813, water-flushable, lead-free flux; ASTM B32, lead-free-alloy solder; and ASTM B828 procedure, unless otherwise indicated.

3.07 TESTING

A. Apply a hydraulic pressure 1-1/2 times the operating pressure, 150-psig minimum, and carefully check for leaks.

B. Remove or isolate valves, expansion joints, strainers and equipment that are rated at pressures less than test pressure.

C. Repair all leaks and retest the system until proven leak tight.

3.08 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.09 TRAINING

A. A Victaulic factory trained representative (direct employee) shall provide on-site training for contractor’s field personnel in the use of grooving tools, application of groove, and product installation. A Victaulic representative shall periodically visit the job site and review installation.

Contractor shall remove and replace any improperly installed products. Refer to 23 2113 Hydronic Piping for Warranty requirements.

3.10 VALVE APPLICATIONS

A. Chilled-Water Piping:
   1. Ball Valves, NPS 2" and Smaller: Two -piece, full port, stainless-steel trim, copper alloy.
   2. Ball Valves, NPS 2-1/2" and Larger: Class 150, full -port, ferrous alloy.
   3. Butterfly Valves, NPS 2" to NPS 12": Single-flange, full lug, 200-psig CWP rating, bronze disc, EPDM liner, ductile iron.
   4. Grooved-End, Ductile-Iron Butterfly Valves, NPS 2" to NPS 8" 300-psig CWP rating, EPDM- encapsulated ductile-iron disc.
   5. Lift Check Valves, NPS 2" and Smaller: Class 125, non-slam type, bronze with TFE disc.
   6. Swing Check Valves, NPS 2" and Smaller: Class 150, bronze with TFE disc.
   7. Swing Check Valves, NPS 2-1/2" and Larger: Class 125, non-slam type, cast-iron, standard.
   8. Grooved-End Swing Check Valves, NPS 2-1/2" and Larger: Grooved-end, ductile-iron, swing check valves.

END OF SECTION 23 0523

SECTION 23 0529
HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASME B31.1 - Power Piping; 2024.

B. ASME B31.9 - Building Services Piping; 2025.

C. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.

1.02 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 230010 - Basic Mechanical Requirements shall be included as a part of this Section as though written in full in this document.

1.03 WORK INCLUDED

A. Pipe, and equipment hangers, supports and associated anchors.

B. Sleeves and seals.

C. Flashing and sealing equipment and pipe stacks.

1.04 QUALITY ASSURANCE

A. Hangers and Supports for HVAC Piping: In conformance with ASME B31.1 and ASME B31.9.

B. Hangers and Supports for HVAC Piping: In conformance with MSS SP-58.

1.05 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division One.

B. Indicate hanger and support framing and attachment methods.

C. Provide delegated design submittal for equipment anchorage as required in specification 230010 – Part 1.

PART 2 - PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

A. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

B. Wall Support for Pipe Sizes 4 Inches and over: adjustable steel yoke and cast iron roller.

C. Vertical Support: Steel riser clamp.

D. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.

E. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roller and stand, steel screws, and concrete pier or steel support.

F. Roof Pipe Supports and Hangers: Galvanized Steel Channel System as manufactured by Portable Pipe Hangers, Inc. or approved equal.
   1. For pipes 2-1/2” and smaller - Type PP10 with roller
   2. For pipes 3” through 8” - Type PS
   3. For multiple pipes - Type PSE - Custom

G. Copper Pipe Support and Hangers: Electro-galvanized with thermoplastic elastomer cushions; Unistrut “Cush-A-Clamp” or equal. Hangers: Plastic coated; Unistrut or equal.

H. Shields for Vertical Copper Pipe Risers: Sheet lead.

2.02 HANGER RODS

A. Galvanized Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.03 INSERTS

A. Inserts: Malleable iron case with galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 SLEEVES

A. Sleeves for Pipes through Non-fire Rated Floors: Form with 18 gauge galvanized steel, tack welded to form a uniform sleeve.

B. Sleeves for Pipes through Beams, Interior Walls, Exterior Walls, Footings, and Potentially Wet Floors: Form with steel pipe, Schedule 40, galvanized.

C. Sleeves for Pipes through Fire Rated and Fire Resistive Floors and Fireproofing: Prefabricated fire rated steel sleeves including seals, UL listed, manufactured by Hilti.

D. Fire Stopping Insulation: Glass fiber type, non-combustible, UL listed.

E. Caulk: Paintable 25-year acrylic sealant.

F. Pipe Alignment Guides: 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.

2.05 MECHANICAL SLEEVE SEALS

A. Modular sealing element unit, designed for field assembly, to continuously fill annular space between pipe and sleeve and create watertight seal.
   1. Approved Manufacturers:
      a. Link-Seal by Garlock Pipeline Technologies (GPT)
      b. Innerlynx by Advance Products & Systems, Inc.
      c. MetraSeal by Metraflex Co.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material, size of pipe, and service requirements.
   3. Pressure Plates: Carbon steel. Include two for each sealing element.
   4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.06 FABRICATION

A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

B. Design hangers without disengagement of supported pipe.

C. Design roof supports without roof penetrations, flashing or damage to the roofing material.

2.07 FINISH

A. Exposed steel hangers, supports, and appurtenances shall be hot-dipped galvanized. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.01 INSERTS

A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams. Coordinate with Structural Engineer for placement of inserts.

B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

C. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.

D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab. Verify with Structural Engineer prior to start of work.

3.02 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as follows:

PIPE SIZE	MAX. HANGER SPACING	HANGER DIAMETER
(Steel Pipe)		
1/2 to 1-1/4 inch	7'-0"	3/8"
1-1/2 to 3 inch	10'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
15 inch and over	10'-0"	7/8"
(Copper Pipe)		
1/2 to 1-1/4 inch	5'-0"	3/8"
1-1/2 to 2-1/2 inch	8'-0"	3/8"
3 to 4 inch	10'-0"	3/8"
6 to 8 inch	10'-0"	1/2"
(Cast Iron Pipe)		
2 to 3 inch	5'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
15 inch and over	10'-0"	7/8"
(PVC Pipe)		
1-1/2 to 4 inch	4'-0"	3/8"
6 to 8 inch	4'-0"	1/2"
10 inch and over	4'-0"	5/8"

B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.

C. Place a hanger within 12 inches of each horizontal elbow, and at the vertical to horizontal transition.

D. Use hangers with 1-1/2 inch minimum vertical adjustment.

E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.

F. Support vertical piping at every floor.

G. For vertical shaft or chase applications where floor slab supported riser clamps cannot be provided to keep the pipe in alignment and to support the weight of the pipe and its contents, ensure to provide suitable fasteners, hardware, braces, unistrut, structural steel members, and appurtenances required to accommodate the pipe installation. Coordinate all such work with the project structural engineer to ensure that necessary members and attachment points are provided accordingly to bear the weight of the functioning piping.

H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

I. Support riser piping independently of connected horizontal piping.

J. Install hangers with nut at base and above hanger; tighten upper nut to hanger after final installation adjustments.

K. Portable pipe hanger systems shall be installed per manufacturer's instructions.

L. Distances between supports are maximum distance. Supports shall be provided to carry the pipe/equipment load.

3.03 INSULATED PIPING

A. Clamps: Attach galvanized clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.

B. Saddles: Install galvanized protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation. Secure the full contact area of the saddle to the pipe insulation with 1/8" thick coat of mastic.

C. Shields: Install protective shields MSS SP-58 Type 40 on cold and chilled water piping that has vapor barrier. Secure the full contact area of the shield to the pipe insulation with 1/8" thick coat of mastic.

D. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

Nominal Pipe Size	Shield Length	GaugeThickness
1/4 through 3-1/2 inch	12	18
4 inch	12	16
5 through 6 inch	18	16
8 through 14 inch	24	14
16 through 24 inch	24	12

E. Piping 2" and larger: provide galvanized sheet metal shields with calcium silicate insulation at hangers/supports.

F. Insert material shall be at least as long as the protective shield.

G. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.04 EQUIPMENT BASES AND SUPPORTS

A. Provide equipment bases of concrete.

B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.

C. Refer to specification 230200 – Part 1 for anchorage requirements for roof mounted equipment.

D. Construct support of steel members. Brace and fasten with flanges bolted to structure.

E. Provide rigid anchors for pipes after vibration isolation components are installed.

3.05 SLEEVES

A. Sleeves shall be provided at the following locations:
1. Piping passing through rated and non-rated floor assemblies, rated ceiling assemblies, and roof assemblies.
2. Piping passing through concrete, masonry, and rated gypsum board walls and partitions.
3. Piping passing through exterior wall assemblies above and below grade.
4. Piping passing through non-rated gypsum board walls and partitions where indicated on the drawings or where exposed to view.
5. Piping passing through structural members where indicated on the drawings or where exposed to view.
6. Any other locations indicated on the drawings.

B. Set sleeves in position in formwork. Provide reinforcing around sleeves.

C. Extend sleeves through floors minimum one inch above finished floor level. Sleeves located in walls, ceilings, and structural members shall be flush with the outer surfaces of the assembly being penetrated.

D. Where sleeved piping penetrates a floor, ceiling, or interior wall assembly, pack annular space between pipe and sleeve with UL listed fire stopping insulation and caulk seal airtight with fire barrier sealant. Provide close fitting metal collar or escutcheon covers at both sides of wall penetrations and exposed side of ceiling penetrations.

E. Install all UL listed, prefabricated fire rated steel sleeves per the manufacturer's installation instructions to ensure fire rating is maintained.

F. Sleeves at exterior walls below grade shall be sealed with mechanical sleeve seal. Install seal per manufacturer's installation instructions. Select type and number of sealing elements required for pipe material, pipe size, and service requirements. Position pipe in center of sleeve. Assemble mechanical sleeve seal and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal. Locations above grade shall be provided with close fitting metal collar or escutcheon covers at both sides of penetration.

END OF SECTION 23 0529

SECTION 23 0548
VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 230010 - Basic Mechanical Requirements shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED

A. Vibration and sound control products.

1.03 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: 125 miles per hour.
   2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Vibration and sound control products shall conform to ASHRAE criteria for average noise criteria curves for all equipment at full load conditions.

C. Unless otherwise indicated, sound and vibration control products shall be provided by a single manufacturer.

1.05 SUBMITTALS

A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.

B. PRODUCT DATA: Submit product data showing type, size, load, deflection, and other required information. Include clearly outlined procedures for installing and adjusting isolators. Submit Drawings for each item of equipment with complete isolation installation information.

C. Submit detailing of inertia bases and locations of vibration, including weight of inertia base.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Include copies of approved submittals and any submittal comments.

C. Provide tab for each major type of equipment (fan coil units, pumps, piping, fans, etc.). Provide schedule of vibration isolator type with location and load on each. Include data on each isolator type that corresponds to:
   1. Spring diameter.
   2. Deflection.
   3. Compressed spring height.
   4. Point location of each isolator.
   5. Calculated load at each point.
   6. Field static deflection.

D. Include copy of written certification from factory representative as required in Part 3 of this specification.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. VMC Group
B. Mason Industries, Inc.
C. Kinetics Noise Control, Inc.
D. Vibration Eliminator Co., Inc.
E. Vibro-Acoustics

2.02 GENERAL

A. Provide vibration isolation supports for equipment, piping and ductwork, to prevent transmission of vibration and noise to the building structure that may cause discomfort to the occupants.
B. Model numbers of VMC Group products are included for identification. Products of the listed manufacturers will be acceptable provided they comply with all the requirements of this specification.

2.03 ISOLATOR DESIGN

A. Materials
   1. Design and treat vibration isolators for resistance to corrosion.
   2. Steel components shall be PVC coated or phosphatized and painted with industrial-grade, corrosion-resistant enamel.
   3. Furnish zinc-electroplated or cadmium plated nuts, bolts and washers.
   4. All isolators exposed to the weather shall have the steel parts hot dip galvanized and a PVC coating.
   5. Clean steel bases thoroughly of welding slag and prime with zinc-chromate or metal etching primer.

B. Design
   1. Unless otherwise instructed, use spring-type vibration isolators for all equipment driven by motors of 3 horsepower and larger.
   2. The isolator manufacturer must calculate the amount of spring deflection required for each isolator to achieve optimum performance and to prevent the transmission of objectionable vibration and noise.
   3. Isolators must be sized for starting torque of equipment motors.
   4. The following minimum spring deflections apply unless noted otherwise in the specifications:
      a. Beltdriven Equipment

Motor Size Horsepower	Installation Above Grade	Installation at Grade or Below
5 -10	1"	1"
15 - 30	1-1/2"	1"
40 - 75	2"	1-1/2

      b. Direct Driven Equipment

Motor Size Horsepower	Installation Above Grade	Installation at Grade or Below
5 -20	1"	1"
25 -75	1"	1"

   5. All spring isolators must be completely stable in operation and must be designed for not less than 30 percent reserve deflection beyond actual operation conditions.
   6. Height saving brackets used with isolators having 2-1/2 inch deflection or greater shall be of the precompression type to limit exposed bolt length.

2.04 BASE MOUNTED PUMPS

A. Provide VMC Group model SP-NR, style E, elastomeric isolation pads consisting of two layers of 3/8'' thick alternate ribbed elastomeric pad bonded to a 16 gauge galvanized steel separator plate.

B. Pads shall be sized for approximately 40 psi loading and 1/8'' deflection.

C. Provide VMC Group model CPF, 8" concrete inertia base. Base shall be welded steel construction with concrete in-fill supplied by the contractor on site and shall incorporate standard rebar reinforcement, spaced a maximum of 12" on center. Provide VMC Group model AWH, floor mounted spring isolators sized for 1 inch static deflection.

D. Provide inertia bases for all base mounted pump applications in which the pumps are to be installed on any floor level other than the ground floor or grade level. Inertia bases shall also be provided for base mounted pump applications in which the associated mechanical room where they are housed is in a noise sensitive location, regardless of floor level.

2.05 PIPING

A. Provide VMC Group model HRS combination spring and elastomeric isolation hangers in mechanical equipment rooms, for a minimum distance of 50 feet from isolated equipment for all chilled water and hot water piping 1-1/2'' diameter and larger. Isolators shall be sized for the same deflection as the isolators specified for the equipment up to a maximum of 2" deflection for at least the first three piping hangers; the remaining hangers shall have isolators sized for 1" deflection.

B. Floor supported piping is required to be isolated with VMC Group model AW-1 open springs sized for 1'' deflection.

C. All condenser water piping shall be supported with VMC Group model AW-1 open springs sized for 1" deflection for floor or roof mounted piping and VMC Group model HRS-1 combination spring and elastomeric isolation hangers sized for 1" deflection for suspended piping.

D. Provide line size flexible connectors at supply and return of pumps, chillers, and all other locations indicated on the mechanical drawings and details. Flexible pipe connectors shall be VMC Group model 2800 single sphere EPDM construction and shall include 150 lb. cadmium plated carbon steel floating flanges.

2.06 CORROSION PROTECTION

A. All vibration isolators shall be designed and treated for resistance to corrosion.

B. Steel components: PVC coated or phosphate coated and painted with industrial grade enamel. Nuts, bolts, and washers: zinc-electroplated.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All equipment shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.

B. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

C. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.

D. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

E. If internal isolation option is used on air handling units, the mechanical contractor shall verify proper adjustment and operation of isolators prior to start-up. All shipping brackets and temporary restraint devices shall be removed.

F. The vibration isolation supplier shall certify in writing that he has inspected the installation and that all external isolation materials and devices are installed correctly and functioning properly.

G. All open-type spring isolators shall be restrained as recommended by the manufacturer.

H. Isolation Bases
   1. The isolated equipment and its driving motor shall be mounted on a common inertia base and the base, in turn, shall be mounted on the scheduled vibration isolator type to prevent transmission of vibration and noise to the building structure.
   2. For floor mounted equipment, provide an equipment (housekeeping) pad under the isolation base.
   3. In general, all inertia bases shall be formed and poured in place onto a hard, flat surface from which the base can be separated when cured. The base shall be shimmed, using flat material, to the intended final height prior to equipment mounting and piping connection.
   4. After piping connections are made and the system filled with water and ready to put into service, the isolator adjustment bolts shall be extended until the shim blocks can be removed. Isolators may then be backed down slightly to restore the intended height. The locknuts should then be tightened on the isolators. Jack bolts shall be trimmed to a length that will allow no more than 1 inch of additional height adjustment. After final adjustment, the inertia base shall not support any piping load. All springs supporting piping that is connected to a piece of isolated equipment shall be sized for static deflection equal to that of the isolated equipment.

3.02 STOCK REQUIREMENTS

A. The isolation manufacturer's representative must maintain an adequate stock of springs and isolators of type used so that changes required during construction and installation can be made.

3.03 ADJUSTING

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

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

C. Adjust active height of spring isolators.

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

3.04 FACTORY REPRESENTATION

A. After installation, furnish factory-trained representative of the isolation manufacturer to check various isolators and report measured versus anticipated deflection on all isolators. Have the representative submit written certification that the isolators have been installed in accordance with the specifications, manufacturer's recommendations and approved submittals.

END OF SECTION 23 0548

SECTION 23 0553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.

B. ASTM C1036 - Standard Specification for Flat Glass; 2025.

C. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

1.02 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:
   1. Equipment nameplates.
   2. Equipment markers.
   3. Pipe markers.
   4. Stencils.
   5. Valve tags.
   6. Valve schedules.

1.03 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.04 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.05 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.01 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal with data engraved or stamped or 2 or 3 ply laminated layers of engraving plastic for permanent attachment on equipment. Minimum 1/8 inch thick. Minimum size is ¾ inch by 2.5 inches.
   1. Data:
      a. Manufacturer, product name, model number, and serial number.
      b. Capacity, operating and power characteristics, and essential data.
   2. Location: Accessible and visible.
   3. Fasteners: Mechanical. No adhesives.
   4. Colors shall comply with JPS standards.

B. Equipment Markers: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2. Fabricate in sizes required for message
   1. Terminology: Match schedules as closely as possible.
   2. Data:

a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
4. Fasteners: Self-tapping, stainless-steel screws.

2.02 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
1. Colors: Comply with JPS standard color scheme:
a. See table below.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

2.03 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect or Engineer. Provide 5/32-inch hole for fastener.
1. Material: 0.032-inch- thick brass or aluminum.
2. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

2.04 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 EXECUTION

3.01 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

B. Locate ceiling tacks to locate valves above T-bar type and hard ceilings. Locate in corner of panel closest to equipment.

C. All above ceiling valve and equipment locations are to have ceiling tags.

D. All major equipment to have a QR Code on it for JPS tracking purposes – code generated by JPS

E. All exposed piping is to be painted.

3.02 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
   1. Pumps

B. Install equipment markers with mechanical fasteners on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
   1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
   3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
      a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
      b. Fire department hose valves and hose stations.
      c. Meters, gages, thermometers, and similar units.
      d. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
      e. Pumps, compressors, chillers, condensers, and similar motor-driven units.
      f. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
      g. Fans, blowers, primary balancing dampers, and mixing boxes.
      h. Packaged HVAC central-station and zone-type units.
      i. Tanks and pressure vessels.
      j. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.03 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow. Minimum letter height is 1.5 inches.
   1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
   2. Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 25 feet along each run.

C. Install underground ribbon marking tape midway between underground piping and the surface.

D. Pipe Label Color Schedule:
   1. All HVAC piping.

a. Use standard JPS pipe label colors

Service	Color (Pipe/Background/Text)	Designation
Primary Chilled Water Supply	Dark blue/Green/White	PCWS
Primary Chilled Water Return	Light Blue/Green/White	PCWR
Secondary Chilled Water Supply	Dark blue/Green/White	SCWS
Secondary Chilled Water Return	Light Blue/Green/White	SCWR
Primary Heating Water Supply	Dark Green/Green/White	PHWS
Primary Heating Water Return	Light green/Green/White	PHWR
Secondary Heating Water Supply	Dark Green/Green/White	SHWS
Secondary Heating Water Return	Light green/Green/White	SHWR
Refrigerant Liquid	No color/White/Black	RL
Refrigerant Suction	No color/White/Black	RS
A/C Condensate Drain	White/Yellow/Black	A/C
Makeup Water	Dark Green/Green/White	MU
Drain	White/White/Black	D

3.04 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; faucets; convenience and lawn-watering hose connections. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:
   1. Valve-Tag Size, shape, and color:
      a. 1-1/2 inches, round, natural color.

3.05 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.06 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.07 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 23 0553

SECTION 23 0593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition; 2016.

B. AMCA 201 - Fans and Systems; 2023.

C. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; Most Recent Edition Cited by Referring Code or Reference Standard.

D. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2024, with Errata (2025).

E. NEBB (TAB) - Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems; 2019, with Errata (2022).

F. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2023.

1.02 SUMMARY

A. This Section includes TAB to produce design objectives for the following:
   1. Hydronic Piping Systems:
      a. Variable-flow systems.
   2. HVAC equipment quantitative-performance settings.
   3. Existing systems TAB.
   4. Verifying that automatic control devices are functioning properly.
   5. Reporting results of activities and procedures specified in this Section.

1.03 SUBMITTALS

A. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in paragraph 3.2, Preparation of this Section. Include a complete set of report forms intended for use on this Project.

B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

C. Warranties specified in this Section.

1.04 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC.

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.05 SCOPE OF WORK

A. Testing, adjusting, and balancing (TAB) of the air conditioning systems, related ancillary equipment and domestic water system will be performed by an impartial technical TAB firm selected and employed by the Owner.

B. As a part of this Contract, the Contractor and/or Mechanical Subcontractor shall make any changes in the sheaves, belts, dampers, valves, etc. required for correct balance as required by the TAB firm, at no additional cost to the Owner.

C. The Mechanical Subcontractor shall provide, and coordinate services of qualified, responsible subcontractors, suppliers and personnel as required to correct, repair, replace any and all deficient items or conditions found during the testing, adjusting and balancing period.

D. In order that all systems may be properly tested, balanced, and adjusted as required herein by these Specifications, the Contractor shall start-up and check-out all systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB. This length of time shall be acceptable to the Owner's Representative.

E. Contract completion schedules shall provide sufficient time to permit the completion of TAB services prior to Owner occupancy.

F. The Drawings and Specifications have indicated valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor or the Inspector shall be corrected by the Contractor immediately so the balancing work can proceed.

G. Contractor must ensure that the necessary systems are scheduled to be in operations for TAB firm so that the access for balancing to diffusers, dampers etc., is not restricted. Contractor must schedule and coordinate activities so that TAB firm is not restricted from performing work, including access to damper operators and air devices.

1.06 PROJECT CONDITIONS

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

1.07 COORDINATION

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

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.08 WARRANTY

A. A.Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
   1. AABC (NSTSB): AABC National Standards for Total System Balance.
   2. Maintain at least one copy of the standard to be used at project site at all times.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. 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.

D. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
   2. Having minimum of three years documented experience.
   3. Certified by one of the following:
      a. AABC, Associated Air Balance Council. Upon completion submit AABC National Performance Guaranty.

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.02 PRE-TAB EXISTING SYSTEMS

A. Perfrom a Pre-TAB on the existing pumps serving the scope area prior to demolition.

B. Provide Pre-TAB report to Owner and Engineer.

C. Coordinate with Owner for after-hours and weekend times to perform the Pre-TAB.

3.03 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
   1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

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

C. Examine Project Record Documents described in Division 01 Section. Project Record Documents.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, Sections 7 through 10; or in SMACNA's "HVAC Systems - Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

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

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine strainers for clean screens and proper perforations.

L. Examine two-way valves for proper installation for their intended function.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.04 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Equipment and duct access doors are securely closed.
4. Isolating and balancing valves are open and control valves are operational.

3.05 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC (NSTSB) and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

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

3.06 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.07 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for

differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
3. 3Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.08 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.09 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
1. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.11 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
   1. Pump curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   3. Project name.
   4. Project location.
   5. Engineer's name and address.
   6. Contractor's name and address.
   7. Report date.
   8. Signature of TAB firm who certifies the report.
   9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   10. Summary of contents including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   11. Nomenclature sheets for each item of equipment.
   12. Data for terminal units, including manufacturer, type size, and fittings.
   13. Notes to explain why certain final data in the body of reports varies from indicated values.
   14. Test conditions for fans and pump performance forms including the following:
      a. Conditions of filters.
      b. Cooling coil, wet- and dry-bulb conditions.
      c. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
   1. Water and steam flow rates.
   2. Pipe and valve sizes and locations.
   3. Position of balancing devices.

3.12 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 23 0593

SECTION 23 0700
INSULATION - GENERAL

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).

B. ASTM C871 - Standard Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions; 2023.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.

D. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; 2006.

E. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.02 WORK INCLUDED

A. This Section specifies the general requirements for furnishing and installing insulation. These requirements apply to all other Mechanical Division sections specifying insulation.

B. All the ductwork and piping in pump rooms, mechanical rooms and equipment rooms including areas without ceilings is to be considered as exposed piping or ductwork. This also includes penthouses, interstitial spaces, and crawlspaces.

1.03 RELATED WORK

A. Internal insulation for air units is specified in the sections on air handling units. The units do not require external insulation.

B. Insulation. Refer to specific sections on individual insulation types.

1.04 FIRE HAZARD RATING

A. All equipment, duct and piping insulation used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements.

1.05 QUALITY ASSURANCE:

A. Applicator shall be a company specializing in insulation application with minimum 5 years' experience.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.06 SUBMITTALS

A. Product Data: Submit product data on each insulation type, adhesive and finish to be used in the work. Include manufacturer's installation instructions, list of materials and thickness for equipment scheduled.

B. Shop Drawings: Show details for the following:

1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Attachment and covering of heat tracing inside insulation.
3. Insulation application at pipe expansion joints for each type of insulation.
4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Removable insulation at piping specialties, equipment connections, and access panels.
6. Application of field-applied jackets.
7. Application at linkages of control devices.
8. Field application for each equipment type.

1.07 DELIVERY, STORAGE, AND HANDLING

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

1.08 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.09 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

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

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are listed under individual specification sections.

2.02 INSULATION

A. Insulate in accordance with appropriate specification section.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

3.02 PREPARATION

A. Surface Preparation: Clean and prepare surfaces to be insulated. Remove materials that will adversely affect insulation application. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.03 COMMON INSULATION REQUIREMENTS

A. All materials shall be delivered to the site shall be dry, undamaged and maintained in good condition throughout the progress of the project.

B. Insulation shall not be installed until all testing and inspection of pipe, duct, vessel, etc. has been completed and approved by Engineer/Owner’s representative.

C. Insulate valves, fittings, flanges and special items in accordance with appropriate specification section.

D. Replace insulation damaged by either moisture or other means. Insulation which has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also replace any damage caused by the condensation.

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

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

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

H. Install insulation with longitudinal seams at top and bottom of horizontal runs.

I. Install multiple layers of insulation with longitudinal and end seams staggered.

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

K. Keep insulation materials dry during application and finishing.

L. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

M. Install insulation with least number of joints practical.

N. Where vapor barrier is indicated, seal joints, duct wrap seams, vapor retarder (ASJ) film seams and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier coating/mastic.
   1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier coating/mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

3.04 ACCESSORIES

A. Installation of accessories such as jacketing, bands, adhesives, insulation shields, coatings, finishes, etc. is specified under individual specification sections.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect field-insulated equipment, randomly selected by TAB, Comisisoning Agent, Engineer, or Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
2. Inspect pipe, fittings, strainers, and valves, randomly selected by TAB, Comisisoning Agent, Engineer, or Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Application and Thickness Schedule" Table.

D. All insulation applications will be considered "Defective Work" if sample inspection reveals noncompliance with requirements.

END OF SECTION 23 0700

SECTION 23 0716
EQUIPMENT INSULATION

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2019, with Editorial Revision (2023).

B. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.

C. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2025.

1.02 WORK INCLUDED

A. This Section provides for furnishing and installing insulation for both high and low temperature vessels and equipment.

B. Low temperature installations include chilled water pumps, heat exchangers, expansion tanks, air eliminators, chilled water storage (buffer) tanks and other vessels containing liquids and gases below 60°F.

1.03 SUBMITTALS

A. Provide Submittals in accordance with Section 23 0700.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Flexible Elastomeric (Type E2)
   1. Armacell
   2. K-Flex USA.

2.02 INSULATION

A. Type E2, Flexible Elastomeric insulation: Provide closed cell expanded rubber materials complying with ASTM C534/C534M, Type 1 for tubular materials or ASTM C534/C534M, Type 2 for sheet materials. Insulation shall have a maximum “K” factor of 0.28 Btu-in./h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C177 or ASTM C518, latest revisions.

2.03 CEMENT AND COATINGS

A. Low Temperature:
   1. Adhesive: Furnish Armaflex 520 BLV Low VOC Adhesive, Foster 85-75 or Childers CP-82 to seal longitudinal labs and to adhere butt joint covers.
   2. Finish: Furnish Armaflex WB or Foster 30-64 water based latex enamel finish.

B. Reinforcing Mesh:
   1. Reinforcing Mesh: Fiberglass or polyester. 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10

PART 3 EXECUTION

3.01 GENERAL

A. Pressure test all piping prior to insulating equipment.

B. Clean surfaces prior to installation and remove all dirt.

3.02 EQUIPMENT INSULATION APPLICATION AND THICKNESS SCHEDULE

SERVICE	APPLICATION	INSULATION TYPE	INSULATION THICKNESS-INCHES

AIR SEPARATORS, EXPANSION TANKS	HOT WATER SYSTEM	E2	2
AIR SEPARATORS, EXPANSION TANKS, STORAGE (BUFFER) TANKS	CHILLED WATER SYSTEM	E2	2
CHILLED WATER PUMP	CHILLED WATER SYSTEM	E2	2
HEAT EXCHANGERS	HOT WATER SYSTEM	E1	1-1/2
HEAT EXCHANGERS	CHILLED WATER SYSTEM	E2	1-1/2
CHILLER COLD SURFACES	AREAS NOT FACTORY INSULATED SUBJECT TO CONDENSATION	E2	TWO 3/4” LAYERS.
PROCESS CHILLED WATER PUMP	PROCESS CHW SYSTEM	E2	1
TERMINAL UNITS (WHERE INDICATED)	SUPPLY AIR SYSTEM	E3	BY MANUFACTURER

3.03 TYPE E2, FLEXIBLE ELASTOMERIC INSULATION

A. Adhere sheet insulation to clean, oil-free metal surfaces by compression fit method and full coverage of adhesive. Seal butt joints with same adhesive. Where two layers are used, stagger joints.

B. Apply finish to cover insulation.

C. Pumps.
1. The pump must be started up with vibration testing completed prior to insulating.
2. Clean pump prior to installation and remove all dirt. Carefully measure and sheets for direct application on chilled water pumps. Apply adhesive to pump and to back side of insulation. Allow adhesive to dry to touch but remain tacky before joining surfaces. Spread butt seams and apply adhesive to both butt edges. Align carefully and join butt edges. Refer to manufacturer’s instructions for further information and details.
3. Provide removable insulation (friction fit) for accessible areas of pump. Ensure pump shaft is insulated on opposite side of motor. Insulation shall not be applied directly to moving surfaces.
4. Apply a finish to the cover as specified above.
5. Install equipment identification nameplate and "spare" manufacturer's pump performance nameplate on pump inertia base with corrosion resistant fasteners.

END OF SECTION 23 0716

SECTION 23 0719
PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

B. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.

C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2019, with Editorial Revision (2023).

D. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2024).

E. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2024).

F. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.

G. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2025.

H. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2022a.

I. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2022.

J. ASTM C1126 - Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation; 2024.

K. ASTM D5590 - Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay; 2017 (Reapproved 2021).

L. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.

M. ASTM F1249 - Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor; 2020.

N. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.02 SECTION INCLUDES:

A. Piping insulation for Chilled and Heating Water Piping within building envelope, other than Crawl Spaces and wet areas.

B. Primary and Secondary chilled water piping shall be considered chilled water piping in these specifications.

C. Furnishing and installation of insulation.

D. Jackets and accessories.

1.03 QUALITY ASSURANCE

A. Applicator. Company specializing in piping insulation application with five years minimum experience.

B. Materials. UL/ULC Classified per UL 723 or Flame spread/fuel contributed smoke developed rating of 25/50 (12.7 mm) accordance with ASTM E84.

1.04 SUBMITTALS

A. Refer to Specification 23 0700.

B. Submit product data on insulating materials, including manufacturer's safety and installation instructions.

C. Include product description, list of materials and thickness for each service, and locations.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Fiberglass
      a. Owens-Corning.
      b. JohnsManville.
      c. Knauff Insulation
   2. Flexible Elastomeric
      a. Armacell; AP Armaflex.
      b. RBX Corporation.

2.02 INSULATION

A. Type P1: Furnish fiberglass insulation with factory applied, all service reinforced vapor barrier (ASJ) jacket having integral laminated aluminum vapor barrier and self-sealing labs. Jacketing shall have a maximum water vapor permeance of 0.02 perms. Insulation shall be in accordance with ANSI/ASTM C547 with a "K" factor of 0.23 (0.23)-in/hr-ft2-°F at 75°F. Insulation shall be certified by Greenguard Gold.

B. Type P2. Furnish closed cell expanded rubber materials complying with ASTM C534, Type 1 for tubular materials or ASTM C534/C534M, Type 2 for sheet materials. Insulation shall have a maximum “K” factor of 0.28 Btu-in./h-ft2- °F at a 75°F mean temperature when tested in accordance with ASTM C177 or ASTM C518, latest revisions.

2.03 INSULATION SHIELDS AND SADDLES

A. Field Fabricated:
   1. Use high compression strength Phenolic Foamglas blocks (HLB 1600) that will support the bearing area at hangers and supports.
   2. Further support insulation at hangers and supports with a shield of galvanized metal extending not less than 2 inches (50.8 mm) on either side of the support bearing area, covering at least half of the pipe circumference, and conforming to the schedule below.
   3. When pipe is guided at top and bottom, metal shields should cover the whole pipe circumference.
   4. Adhere metal shield to insulation so that metal will not slide with respect to insulation. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).

Pipe Diameter	Insulated Section Length in Inches	Minimum U.S. Standard Gauge of Metal Shield
2 1/2” and smaller	14	16
3” to 4”	14	16
6” to 12”	24	14
14” and larger	24	12

   5. At Contractor's option, factory-made insulation shields may be provided as made by Anvil Fig 168, equivalent by Pipe Shields, Inc., or equal. Insulation should extend at least 1 inch (25.4 mm) beyond metal. Select proper shield for service and pipe span.
   6. For Type P2 insulation, factory-made insulation shields such as Armafix IPH may be used at Contractor’s option.

7. For Type P5 insulation, use minimum 5-pound density insulation or denser as required by manufacturer at all pipe supports.

B. Saddles: Fit piping 2 inches (50.8 mm) through 10 inches (254 mm) operating at high temperatures with Anvil Figure 161 through 164 protection saddles, or similar saddles of proper design for specified insulation thickness. Fit pipe sizes over 10 inches with Anvil Figure 163A through 165A or similar saddle as required by insulation thickness specified.

C. All shields are to be secured by 2 stainless steel bands, 1/2-inch-wide by 0.015-inch-thick with matching seals

2.04 JACKETS

A. PVC Jackets: Provide molded or mitered covers for flanges, valves and fittings similar to Schuller Zeston 2000.

2.05 SEALANT, ADHESIVE AND FINISH

A. Fiberglass - Low Temperature (Below 70ºF):
1. Flashing Sealant: Furnish Childers CP 76 or Foster 95-44 elastomeric sealant at valve covers, anchors and hangers.
2. Lap Adhesive: Furnish Childers CP-82 or Foster 85-20 to seal longitudinal laps of the vapor barrier jacket and to adhere butt joint covers.
3. Vapor Barrier Coating: Furnish Childers CP-38 or Foster 30-80 with reinforcing mesh on all insulated fittings, flanges, and valves. Permeance shall be 0.05 perms or less as tested by ASTM E96, Procedure A at 47 mils (1.1938 mm) dft or 0.08 perms or less as tested by ASTM F1249. Coating must comply with MIL-PRF-19565C, Type II and be QPL listed All ASJ seams shall be coated with vapor barrier coating to prevent moisture ingress. Outdoors: Foster 30-90; Childers CP-35 only. White
4. Vapor Barrier Coating: Furnish Foster 30-80 AF with reinforcing mesh on all insulated fittings, flanges, and valves. Coating shall meet ASTM D5590 with 0 growth rating. Maximum permeance shall be no greater than 0.08 perms at 37 mils (0.9398 mm) dry as tested at 100°F and 90% RH per ASTM F1249. All ASJ seams shall be coated with vapor barrier coating to prevent moisture ingress. Outdoors: Foster 30-90; Childers CP-35 only. White.

B. Flexible Elastomeric
1. Adhesive: Furnish Armaflex 520 BLV Low VOC Adhesive, Foster 85-75, or Childers CP-82 to seal longitudinal labs and to adhere butt joint covers.
2. Finish: Furnish Armaflex WB or Foster 30-64 water based latex enamel finish.

C. Reinforcing Mesh: Fiberglass or polyester. 10 strands by 10 strands per square inch. Similar to Foster Mast A Fab or Childers Chil Glas #10

2.06 FITTINGS

A. Provide pre-molded fittings and elbows molded in two matching half sections of same insulation thickness as adjoining piping. As an alternative, provide mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs. No insert or blanket insulation allowed.

2.07 PRIMER

A. Polyguard RG-CHW for surface temperatures less than 130F, RG-2400 LT for piping with surface temperatures between 130F and 250F. Application thickness shall be 25 mils (0.635 mm).

B. Global Encasement Rust Inhibition Primer. Application thickness shall be minimum 3 mils (0.0762 mm)

C. Sherwin Williams Pro-Cryl Universal Acrylic Primer. Application thickness shall be minimum 3 mils (0.0762 mm).

2.08 ALUMINUM JACKET

A. Piping. Furnish for finishing interior insulated pipe, a prefabricated jacket of ASTM B209 aluminum, 0.020-inch-thick, with factory-applied 2-mil moisture barrier.

B. Valves, Fittings and Flanges. Provide complete coverage of all valves, fittings and flanges, provide aluminum covers, 0.020-inch-thick, ASTM B209 aluminum.

C. Straps and Seals. Furnish 1-inch x 0.010 inch (0.25 mm), ASTM B209 aluminum strapping and seals for applying aluminum jacket and covers to provide completely weather tight covering of all insulation including caps, flanges and end of lines.

D. Metal Jacketing Sealant: Furnish 1/8” bead of Foster 95-44 or Childers CP-76 underneath all metal jacketing laps to prevent water entry on outdoor applications.

PART 3 EXECUTION

3.01 PIPE

A. Pressure testing of piping systems shall be complete prior to application of insulation.

B. Prior to insulating piping,
   1. Remove all oil, grease, cutting oils, dirt and other contaminants. Use suitable solvents, steam cleaning with detergent, or freshwater wash with detergent. Follow with thorough freshwater rinse.
   2. Provide primer coat on all chilled water steel piping in accordance with manufacturer’s recommendations, to include field welds and over factory applied paint/coating, in total compliance with mechanical identification section and compatible with and approved by the insulation manufacturer. Painting must be completed and approved prior to installation of insulation.

C. Butt insulation joints firmly together. Seal longitudinal laps and butt strips with sealant.

D. Type P1 Fiberglass or P5 Phenolic Foam - Low Temperature:
   1. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet (762 cm) on straight runs, an isolating vapor seal shall be formed between the vapor barrier jacket and the bare pipe by liberal application of the vapor barrier sealant to the exposed joint faces carried continuously down to and along 4 inches (101.6 mm) of pipe and up to an along 2 inches (50.8 mm) of the jacket.

E. Type P2.
   1. Provide finish as specified on all insulation.

3.02 VALVES, FLANGES AND FITTINGS

A. Low Temperature:
   1. Insulate all valves, flanges and fittings with molded fitting covers secured with wire. Thickness of insulation shall be equal to that adjoining piping.
   2. Finish with two coats vapor barrier coating reinforced with reinforcing mesh. The application shall provide a minimum dry film thickness of 37 mils (0.9398 mm).

3.03 CONTROL VALVE COVERS - LOW TEMPERATURE SERVICE ONLY

A. Fabricate special covers, complete with troweled-on vapor seal, shaped to accommodate the valve stem. Insulation thickness shall be same thickness as adjoining pipe.

B. Seal covers to valve insulation proper with adhesive so that the seal may be broken with a knife blade without damage to either part. Arrange so that cover can be removed and replaced as necessary for operation of the valve. Finish valve cover with two coats of vapor barrier coating and reinforcing mesh.

3.04 SHIELDS AND HANGERS

A. When the insulation is jacketed in aluminum, install a length of 40-pound roofing felt 1/2 inch (12.7 mm) longer than the insulation shield between shield and jacket.

B. Where piping hangers or anchors must be in direct contact with pipe, seal off the pipe insulation on both sides of the hanger by carrying the vapor seal down to the bare pipe. Apply insulation around the hanger ring or anchor and pipe and carry vapor barrier upward and outward along the hanger rod or anchor members to a point not less than 12 inches (304.8 mm) from the adjacent pipe. Draw wire loops tight over the vapor barrier jacket, with ends of wire bent down. Take care to avoid puncturing the vapor seal. Finish insulation as specified for flanges, and seal over adjacent vapor barrier jacket.

3.05 INSTALLATION

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

B. Continue insulation with vapor barrier through penetrations.

C. In exposed piping areas, locate insulation and cover seams in least visible locations. For outdoor installations seal jacket lap with 1/8” bead of metal jacketing sealant underneath each lap to prevent infiltration of water beneath jacket. On horizontal piping place overlap at side of pipe arranged so that water will run off of jacket and not into seam lap.

D. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

E. Neatly finish insulation at supports, protrusions, and interruptions. Use 1-1/2-inch Type P2 insulation to insulate drains gauges, thermometers, and strainers.

3.06 PIPING INSULATION APPLICATION AND THICKNESS SCHEDULE

A. Provide insulation with minimum thickness and conductivity values in compliance with ASHRAE standard ASHRAE Std 90.1 I-P, Table 6.8.3-1,2, but not less than thicknesses specified in this specification and as required to prevent condensation. Where multiple materials are listed for a single service and location, it is the Contractor’s option to choose from the allowable insulations.

Service	Location	Insulation Type	Pipe Sizes	Insulation Thickness-Inches
Chilled Water	Interior	P2	1-1/2” and smaller	1
Chilled Water	Interior	P2	2” to 6”	1-1/2
Chilled Water	Interior	P2	8” and larger	1-1/2
AHU/FCU Condensate Drains	Interior	P2	All sizes	1
Heating Hot Water	Interior	P1	1-1/4” and smaller	1-1/2
Heating Hot Water	Interior	P1	1-1/2” to 4”	2
Heating Hot Water	Interior	P1	6” and larger	2-1/2
Supports, protrusions, drains, gauges, thermometers and strainers	Interior/ Exterior	P2	All Sizes	1-1/2
Flexible Pump Connector	Chilled Water	P2	All Sizes	1-1/2
Refrigerant Suction Piping	Interior/ Exterior	P2	All Sizes	1
Chilled Water and Heating Hot Water	Crawl Space/ Exterior	P5	1-1/2” and smaller	2
Chilled Water and Heating Hot Water	Crawl Space/ Exterior	P5	2” to 6”	2-1/2

Chilled Water and Heating Hot Water	Crawl Space/ Exterior	P5	8” and larger	2-1/2
Chilled and Heating Hot Water	Crawl Space/ Exterior	Alternate	Refer to Section 23 07 19.11	
Chilled and Heating Hot Water	Below Grade		Refer to Section 23 21 13.13	

3.07 ALUMINUM JACKET

A. Apply aluminum jacket and covers according to manufacturer’s recommendations, using aluminum strapping and metal jacketing sealant to provide completely weathertight covering. Completely encapsulate insulation on all piping, valves, flanges, reducers, etc.

B. Provide aluminum jacket for all piping within 84 inches (2133.6 mm) of finished floor in air handler mechanical rooms, pump rooms, penthouses and exposed occupied spaces in the building. Do not install jacketing on AHU Condensate drains unless noted otherwise. Do not install jacketing on flexible pump connectors or expansion joints.

END OF SECTION 23 0719

SECTION 23 0800
HVAC SYSTEMS TECHNICAL COMMISSIONING 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.

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

A. The purpose of this Section is to define responsibilities in the Commissioning Process. Additional system testing is required within individual Specification Sections.

B. Commissioning requires the participation of the Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. General Commissioning requirements and coordination are detailed in Division 01. Division 20-25 Contractors shall be familiar with all parts of Division 01 and the Commissioning Plan issued by the Owner's CxA, shall execute all Commissioning responsibilities assigned to them in the Contract Documents and include the cost of Commissioning in the Contract price.

C. HVAC systems to be commissioned include the following (some may not apply – refer to the Plans and other sections of the specifications for the scope of work):
   1. Cooling
   2. Pumps
   3. HVAC / Building Automation System and Integrations
   4. HVAC / Emergency Power Source Integrations
   5. HVAC / Life Safety Systems Integrations

D. The TAB Contractor will perform control sequence verification on each terminal unit shall independently verify each sensor and point and document the results to be included in the Final TAB Report. The CxA will commission approximately 50% of the terminal units once TAB is complete with the CSV and point verification of the terminal units. Contractor to provide personnel and all support necessary for this effort.

1.03 DEFINITIONS

A. Refer to the General Commissioning Requirements for definitions.

1.04 SUBMITTALS

A. Contractor shall provide Owner and/or CxA with documentation required for Commissioning Work. At minimum, documentation shall include: Detailed Start-up procedures, full sequences of operation, Operating and Maintenance data, performance data, control drawings, and details of Owner-contracted tests.

B. Shop drawings and product submittal data related to systems or equipment to be commissioned.

C. Contractor shall submit to Owner and/or CxA installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.
   1. Where installation testing may be performed in a progressive manner (i.e., piping hydrostatic testing, ductwork pressure testing, etc.), the Contractor shall prepare and submit to the Owner, A/E team and CxA a testing plan that details how the progressive testing will be performed, documented, and presented for approval prior to the start of any testing activities.

D. Contractor shall provide any additional documentation needed to complete the requirements of the Commissioning Process

1. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPTs.
2. Pre-functional Performance Checklists: review and compile all information associated with the piece of equipment to be commissioning ensure the equipment is ready for final commissioning.
3. Installation testing reports such as ductwork pressure testing, piping hydrostatic testing, piping chemical treatment and flushing, bolt flange torquing, and any documentation associated with local code authority inspections or authorizations.
4. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation.
5. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. All materials and installation shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Refer to the General Commissioning Requirements for other work products related to the Commissioning Process

C. Contractor is required to follow all applicable industry and site-specific safety practices, lockout / tagout requirements, specialized PPE requirements, and provide qualified, trained personnel to execute Commissioning Process requirements.

2.02 TEST EQUIPMENT

A. Contractor shall provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

B. All specialized tools, test equipment, and instruments required to execute Start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and/or measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable. Contractor must calibrate test equipment and instruments according to manufacturer's recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.

PART 3 EXECUTION

3.01 CONSTRUCTION PHASE

A. In each purchase order or subcontract that is written for changes in scope, include the appropriate requirements for submittal data, Commissioning documentation, testing assistance, Operating and Maintenance (O&M) data, and training, as a minimum.

B. Attend Pre-Commissioning Meeting(s), Pre-Installation Meeting(s), and other Project meetings scheduled by the Owner, CxA or Contractor to facilitate the Commissioning process.

C. Provide manufacturer's data sheets and shop drawing submittals of equipment.

D. Provide additional requested documentation to the Owner and/or CxA, prior to O&M manual submittals, for development of System Verification Checklists and Functional Performance Testing procedures.
   1. Typically, this will include detailed manufacturer's installation and Start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, full factory testing reports, if any, and full warranty information.
   2. In addition, the installation, Start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Contractor and/or CxA.
   3. This information and data request may be made prior to normal submittals.

E. With input from the BAS vendor and A/E, clarify the operation and control of commissioned equipment in areas where the Specifications, BAS control drawings, or equipment documentation are not sufficient for writing detailed test procedures.

F. During the installation, Start-up and initial checkout process, execute and document related portions of the System Verification Checklists for all commissioned equipment according to the procedures indicated in the Commissioning Plan.

G. Factory Start-ups: Factory Start-ups are specified for certain equipment. Factory Startups generally are Start-up related activities that will be reviewed and checked prior to Functional Performance Tests. All costs associated with factory Start-ups shall be included with the contract price unless otherwise noted. Notify the Commissioning Team of the factory Start-up schedule and coordinate these factory Start-ups with witnessing parties. The Commissioning Team members may witness these Start-ups at their discretion.

H. Independent Testing Agencies: For systems that specify testing by an independent testing agency, the cost of the test shall be included in the Contract price unless otherwise noted. Testing performed by independent agencies may cover aspects required in the System Verification Checklists, Start-ups, and Functional Performance Tests. Coordinate with the independent testing agency so that CxA, Owner and/or A/E can witness the test to ensure that applicable aspects of the test meet requirements.

I. Incorporate manufacturer's Start-up procedures with System Verification Checklists (SVC).

J. Air and water test, adjust and balance shall be completed with discrepancies and problems remedied before Functional Performance Tests of the respective air or water related systems are executed.

K. Provide skilled technicians to execute starting of equipment and to assist in execution of Functional Performance Tests. Ensure that they are available and present during the agreed-upon schedules and for a sufficient duration to complete the necessary tests, adjustments, and problem solving.

L. Correct deficiencies (differences between specified and observed performance) as interpreted by the Owner's Project Manager and A/E and retest the system and equipment.
   1. CxA shall participate in one retesting effort at no cost to the Owner nor contractor. Should a 2nd retesting effort be required due to system indicating the same or similar issue, then the contractor shall be charged for their effort and the Owner retains the right to withhold the cost of the CxA's additional attendance from the contractor retainage at a maximum of $2,500 per occurrence.

M. During construction, maintain as-built marked-up Drawings and Specifications of all Contract Documents and Contractor-generated coordination Drawings. Update after completion of Commissioning activities (include deferred tests).

N. Provide training of the Owner's operating personnel as specified.

O. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

3.02 WARRANTY PHASE

A. Execute seasonal or deferred tests, witnessed by the CxA and Owner, according to the Specifications.

B. Complete deferred tests as part of this Contract during the Warranty Period. Schedule this activity with the Owner and/or CxA.

C. Correct deficiencies and make necessary adjustments to O&M manuals, Commissioning documentation, and as-built drawings for applicable issues identified in any deferred or seasonal testing.

3.03 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. All installation shall be in accordance with the Project Documents.

3.04 TRAINING

A. Refer to the individual section of this Specification for specific training requirements on each system.

B. Refer to the General Commissioning Requirements and Division 01 for overall training requirements related to the Commissioning process and this project.

END OF SECTION 23 0800

SECTION 23 0963
ENERGY MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).

B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

C. NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response; 2022.

D. NSF 61 - Drinking Water System Components - Health Effects; 2024.

E. NSF 372 - Drinking Water System Components - Lead Content; 2024.

F. UL 916 - Energy Management Equipment; Current Edition, Including All Revisions.

G. The Energy Management and Control System (EMCS) shall be comprised of a Local Area Network (LAN) infrastructure, Operator Workstations (OWS), Engineering Workstations (EWS), a Primary Network Server (PNS), Network Area Controllers (NAC), Application Specific Controllers (ASC), Unitary System Controllers (USC), and Field Devices installed within the facility. The EMCS Contractor shall provide a completely wired system. Wireless components and wireless communication are not acceptable.

H. If the EMCS contractor wishes to connect to the Owner's Wide Area/Local Area Network as part of the control system network, the EMCS contractor shall acquire permission in writing and include the letter in the submittal. Any system that requires connection to the owner's network for communication between NAC, ASC, USC and/or field devices that is submitted without the written permission from the owner shall be rejected. The EMCS Contractor shall coordinate with the Owner and supply all required information.

I. Access to the system, either locally in the building, or remotely from a central site or sites, shall be accomplished through standard web browsers, via the Internet and/or a local area network.

J. All EMCS controllers and workstations shall communicate using the protocols and network standards as defined by ASHRAE Std 135, latest revision. Management level TCP/IP Ethernet network speeds shall be 1 Gbps minimum and the Automation Level MS/TP network speeds shall be 76.8 Kbps minimum.

K. The EMCS shall directly control HVAC equipment as specified in the Sequence of Operations. Furnish Energy Conservation features such as Optimal Start/Stop, Night Setback, Setpoint Reset logic, and Demand Control Ventilation.

L. The EMCS vendor shall provide the following additional services as part of this specification: warranty and service during the warranty period; submittals, samples and record documentation; comprehensive startup and testing of the EMCS with documentation; training services for the owner and facility operators; coordination with other contractors and suppliers; operator and technician training program, and shall cooperate fully with the Project Commissioning Agent.

M. Products furnished under this specification but installed by others.
   1. Mechanical devices installed under Division 23 by the mechanical contractor or other suppliers:
      a. Temperature sensing thermowells.
      b. Automatic control valves and actuators.
      c. Pipe taps for flowmeters.
      d. Water pressure sensors and switches.
   2. Electrical devices installed under Division 26 by the electrical contractor:

a. 120 VAC power to controllers and control panels at locations indicated on the drawings. Review and verify that these locations are adequate for the proposed EMCS.

N. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

1.02 RELATED WORK IN OTHER SECTIONS

A. Refer to Division 00 and Division 01 for allowances and related contractual requirements.

B. Refer to Division 21 for General Fire Protection Provisions and fire suppression pump.
1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP is acceptable if IP interface is not available from equipment manufacturer.
2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.

C. Refer to Division 23 for General Mechanical Provisions for equipment such as chillers, cooling towers, boilers, pumps, air-handling units, terminal units, ventilation fans, variable frequency drives, unitary AC units, etc.
1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP is acceptable if IP interface is not available from equipment manufacturer.
2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.

1.03 ELECTRICAL POWER PROVISIONS

A. Primary power will be provided under Division 26 by the electrical contractor to the panel locations indicated on the mechanical & electrical drawings. Provide step down transformers within panel enclosures. Provide all necessary fuses and circuit protection devices.

B. Power will be provided to the controllers serving fan powered terminal units with electric heat via the control transformer provided with the unit.

C. All components of the EMCS shall be powered from the sources above. Provide final terminations from the locations indicated on the Division 23 Drawings.

D. The EMCS Contractor shall provide any additional control power that is required as part of this contract and not indicated by other. This shall include all conduit, cabling, circuit breakers, etc.

E. Controllers must remain powered even if the equipment they control is disabled. If hardwired interlocks or relays could interrupt controller power, the controllers shall use an independent power circuit to ensure continuous reporting to the EMCS.

1.04 CONTRACTOR QUALIFICATIONS

A. The EMCS Contractor shall:
1. Have a local staff of trained personnel capable of giving instructions and providing routine and emergency maintenance on the EMCS, all components and software/firmware and all other elements of the EMCS.
2. Have a proven record of experience in the supply and installation of equivalent BACnet systems over a minimum period of five years. Provide documentation of at least three equal and complexity, if so requested by the Owner's Representative.
3. Be a factory certified representative of the native BACnet EMCS manufacturer for design, installation, and service of the proposed system.
4. Have comprehensive local service, training and support facilities for the total EMCS as provided. Maintain local, supplies of essential expendable parts.

1.05 SUBMITTALS

A. ALL DOCUMENTS SUBMITTED SHALL BE IN NATIVE PDF FORMAT. NO SCANS.

B. Shop Drawings:

1. The following information shall be included on the cover page for each shop drawing and equipment documentation submittal:
   a. Project name with date. Refer to the applicable specifications by name and number.
   b. Provide submittal number and re-submittal number and date as applicable.
   c. Provided name and address of Consulting Engineer, Mechanical Contractor, General Contractor
2. Shop drawings shall be CAD generated, plot size of 8-1/2” x 11” or 11” x 17”. Drawings shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all aspects of the system to be installed.
3. Provide schematic of systems indicating instrumentation locations, all interconnecting cables between supplied cabinets on a mechanical floor plan.
4. Software specifications and descriptions including operating sequences.
5. Provide a bill of material that indicates specific manufacturer, part number, part description and quantity of each device for all system components.
6. Provide a list of the wire labels to be installed on each end of the control wiring, at the device and the control panel terminal. Labels shall be machine generated, typed and legible with a maximum of 17 characters. The label description “AHU-1 SAT” shall indicate the supply air temperature of AHU-1.
7. Equipment Schematic: Provide an electronic equipment schematic for each piece of mechanical equipment. The schematic shall display all mechanical equipment characteristics including fans, dampers, valves, sensors and other applicable control devices. The schematic shall show wiring terminations to each control device as shown in the submittal and as-build documentation. Control devices shall be labeled by a symbol that can easily be identified in a bill of material that is shown on this graphic. The bill of material shall show the device symbol, description, manufacturer and part number.
8. Sequence of Operations: The control sequences shall be viewable for each piece of mechanical equipment and be in a text format as shown in the as built documentation. The sequence of operations shall be selectable at the applicable location for the control program.

C. Control component submittals:
   1. Component technical data sheets with mounting and installation details.
   2. The documentation shall include comprehensive and complete details of the BIBB and automation level documentation including address, associated controller type, etc. as required and for the interface to the EMCS.
   3. Details of networks/communications equipment, cabling and protocols proposed. Provide schedule of cabling including details of proposed cable types.
   4. Module Drawing: Provide an electronic wiring diagram of each control module (as shown in submittal documentation). Diagram shall display wiring schematic and terminations to end devices. Diagram shall display each input and output terminals and label those that are used for the control application. Diagram shall display module type/name and network address.
   5. Field sensor and instrumentation specification sheets. Provide complete manufacturer’s specifications for all items that are supplied. Include vendor name of every item supplied.
   6. Schedule and specification sheets for dampers, valves and actuators.
   7. Design and provide layout of all components of panel mounted control devices, terminal strips and power supplies.

D. Color graphics: Provide sample layout of color graphic representations of the systems for review. The submittal shall indicate the quality of the graphic to be provided with the system with a sample of the specific control points to be included. Control points shall as a minimum include points indicated in the input/output summary, control schematic and primary controlling points defined in the sequences of operation. Provide a sample of a floor plan layout, typical AHU, terminal unit, outside air pretreatment unit, variable frequency drive, exhaust/supply fan, chiller plant and hot water plant. For control points to be provided by equipment BACnet integration provide sample of the control points, up to 25 total.

E. Verification Reports: The submittal shall include a sample of the verification reports to be utilized during the verification section of this specification. Sample reports shall be approved as submitted or be modified by the engineer or owner's representative. The verification reports shall be included in the final Operation & Maintenance Manuals. Reports shall be provided in electronic PDF format.
   1. Project Systems Verification Form for each controller.
      a. General information for each form shall include: project name; associated equipment with mark number; control panel number and location; controller number and model number; controller device instance number (address); MS/TP LAN segment number; verifying technician and date.
      b. Each connected control point and device shall contain the following columns with a separate line for each connected physical point: point description (same as device label); input/output number for each connected control device (AI-XX, AO-XX, DI-XX, or DO-XX).
      c. Check boxes confirming that the verification tasks have been completed: device location, proper termination at device; proper termination at control panel; sequence is verified; point trend is enabled.
      d. Data entry boxes indicating measured/confirmed values: preliminary control point value on the graphic; observed control point value; calibration or adjustment value to correct offset; final displayed point value on the color-graphic; date of verification; engineer or owner's representative verification.
   2. Control Panel Verification Form for each control panel.
      a. General information: panel location and identification number; panel dimensions and NEMA rating; panel properly installed; Class 1 and Class 2 wiring are properly separated; correct voltage to the panel; no shorts or grounds in panel; no induce voltages in panel wiring; point to point termination match submittal; devices are mounted in the correct location; controller software revision number; address of controllers; panel device checkout is complete; panel startup is complete.
   3. Sequence of Operation Verification Form per piece of equipment (AHU, VAV, chiller, boiler, etc.).
      a. General information: project name; system identifier; building area served; control panel and controller numbers; controller model number and instance number (address); MS/TP LAN segment number; name of verifying technician and date.
      b. Each step of the sequence of operation for each piece of equipment shall be documented shall include a "description of test", "input to trigger test" and "expected outcome". A pass/fail checkbox shall indicate each of these actions. Provide space for technician approval with associated date.

F. Operating and Maintenance (O&M) manuals: Provide O&M manual with full information to allow the owner to operate, maintain and repair installed products. Include trade names with model numbers, color, dimensions and other physical characteristics.
   1. Format: Produce on 8-1/2 x 11-inch pages, and bind in 3-ring/binders with durable plastic covers. Label binder covers with printed title "OPERATION AND MAINTENANCE MANUAL", title of project, and subject matter and "Number _ of _" of binder. Provide substantial dividers tabbed and titled by section/component number.
   2. Table of Contents for each volume:
      a. Part 1: Directory with name, address and telephone number of Designer, Contractor and Subcontractors and Suppliers for each Project Manual section.
      b. Part 2: Operation and maintenance instructions, arranged by Project Manual Section number where practical and where not, by system. Include:
   3. Product design criteria, functions, normal operating characteristic and limiting conditions. Installation, alignment, adjustment, checking instructions and troubleshooting guide. Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown. Test data and performance curves.

4. Spare parts list for operating products, prepared by manufacturers including detailed drawings giving location of each maintainable part, lists of spares recommended for user-service inventory and nearest source of in-stock spares.

G. Record Documentation:
1. Details of all alarm, diagnostic, error and other messages. Detail the Operator action to be taken for each instance.
2. Detail special programs provided and provide a complete programming instruction manual. Detail operation of all software applications.
3. Detailed list of the database for all installed devices.
4. Record drawings shall be CAD generated and shall include final locations and point ID for each monitored and controlled device.
5. In additional to the required hard-copies, provide a CD-ROM with all of the record documentation in PDF format and a CD-ROM containing backup copies of all installed software and graphics.
6. Online as-built documentation: provide digital replications of as-builts that shall be accessible from each equipment graphic controlled or monitored by the EMCS.

1.06 WARRANTY

A. Warranty work and the equipment provided under this contract shall be for a period of one year from the date of Substantial Completion. Warranty shall cover all components, system software, parts and assemblies supplied by this contractor and shall be guaranteed against defects in materials and workmanship for one (1) year from the date of Substantial Completion. Labor to troubleshoot, repair, reprogram or replace system components that have failed due to defects in materials and workmanship shall be provided by this contractor at no charge to the owner during the warranty period. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks. All warranty work shall be performed by the EMCS contractor’s local service group.

B. Warranty shall not include routine maintenance, e.g., equipment cleaning, mechanical parts lubrication, pilot lamp replacement, operational testing, etc. Warranty shall not cover repair or replacement of equipment damaged by under- or over-voltage, misuse, lack of proper maintenance, lightning, water damage from weather or piping failure.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the EMCS contractor. The maximum acceptable response time to provide this service at the site shall be 24 hours, during normal working hours.

PART 2 - PRODUCTS

2.01 GENERAL

A. The existing building automation system is J.

B. Any new controllers shall be able to integrate into the existing system.

C. The existing control sequences shall be applied to the new equipment.
1. The control sequences on the drawings are for general conformance.

2.02 ACCEPTABLE EMCS VENDORS

A. JOHNSON CONTROLS - Branch Office

B. No other vendors are acceptable.

2.03 APPLICATION SPECIFIC CONTROLLERS (ASC)

A. All devices required for single loop control shall be terminated on a single controller. (for example, CHW loop pressure control. The differential pressure sensor and the pump VFD ramp signal.)

B. ASCs shall be capable of implementing control strategies for the system based on information from any or all connected inputs. The AC shall utilize factory pre-programmed global strategies that may be modified by field personnel on-site. Global control algorithms and automated control functions should execute via a 32-bit processor

C. Programming shall be object-oriented using control program blocks that will support a minimum of 500 Analog Values and 500 Binary Values. Analog and binary values shall support standard BACnet priority arrays. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing.

D. Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1 year (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium type. The onboard, battery-backed real time clock must support schedule operations and trend logs.

E. The base unit of the ASC shall host various I/O combinations including universal inputs, binary outputs, and switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.

F. All binary outputs shall have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. The position of each HOA switch shall be available system wide as a BACnet object.

G. Controller shall be capable of BACnet communication. BACnet Conformance:
   1. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. All necessary tools shall be supplied for working with proprietary information.

H. Schedules: Each ASC shall support a minimum of 10 BACnet schedule objects.

I. Logging Capabilities: Each controller shall support a minimum of 100 trend logs. Sample time interval shall be adjustable at the operator’s workstation. Controller shall periodically upload trended data to system server for long term archiving if desired. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

J. Alarm Generation: Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures. Alarm logs shall be provided for alarm viewing. Log may be viewed on-site at the operator’s terminal or off-site via remote communications. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects -system destination and actions individually configurable.

2.04 UNITARY SYSTEM CONTROLLERS (USC)

A. All devices required for single loop control shall be terminated on a single controller. (for example, cooling coil control valve control. The temperature sensor and the valve control signal.)

B. The EMCS Contractor shall provide all Unitary System Controllers. USCs shall be fully programmable or applications specific controllers with pre-packaged operating sequences maintained in Flash RAM.

C. The USC shall be a node on the automation network and shall control its own communications so that the failure of any one node, shall not inhibit communications on the network between the remaining nodes. USCs shall be totally independent of other network nodes for their monitoring and control functions.

D. Provide each USC with a battery back-up for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a seven-year life.

E. All associated applications programs shall reside at the USC. The USC shall not require communication to any other panel for normal operating sequences other than time scheduled base commands.

F. Control shall be based on algorithms, i.e. proportional plus integral plus derivative (PID), proportional plus integral (PI), or proportional to comply with the sequences of operation PID algorithms shall maintain the system operation within +/- 2% of setpoint.

G. The USC shall be configured with sufficient input/output capacity to achieve the required control points to meet the sequence of operations.

2.05 EMCS CONTROLLER LEVEL NETWORK

A. EMCS Automation Level Network shall consist of BACnet MS/TP (76.8 Kbps minimum). Data transfer rate and data throughput as required to meet the alarm annunciation requirements.

2.06 FIELD INSTRUMENTATION

A. Temperature Sensors: All temperature sensors shall be thermistor type, factory-calibrated to within 0.5 °F, interchangeable with housing appropriate for application. Sensors shall have a temperature curve rated for the application. Sensor wiring terminations shall be in a galvanized box.
   1. Thermowell temperature sensors shall be stainless steel probe of length that is equivalent to a minimum of 50% of the pipe diameter. End-to-end accuracy shall be ± 0.5 deg. F. Connection box shall be moisture/water proof with conduit fitting. Furnish the stainless steel thermowell to the mechanical contractor for installation. A thermal conducting grease shall be installed in the thermowell to provide uniform temperature sensing.

B. Pressure Transducers:
   1. Water pressure transducer: The pressure transducers shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 VDC or 4-20 mA. The accuracy shall be +/- 0.25% FS. Transducer shall be SETRA Model 230 or equivalent. Transducer shall include a valved piping bypass and bleed off for each port. Water pressure sensors and all associated tubing, hardware, and accessories shall be provided as appropriate for the application.

C. Momentary control relays: Provide momentary control relays as indicated. Relays shall have coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application. Contact ratings shall be 10 amp. Provide complete isolation between the control circuit and the digital output. Relays shall be located in the UC or other local enclosures and have pin-type terminals. Relays shall have LED indication of status.

D. Current sensing relay: Current sensing relays shall be rated for the applicable load. The output relay shall have an accessible trip adjustment over its complete operating range. Enclosure shall have an LED to indicate relay status.

E. Photocell: Ambient light level shall by a photocell in a non-corroding in a weatherproof housing with sun shield suitable for exterior installation. The control signal output shall be 4-20 ma or binary contact closure as specified in the sequences of operation. Mount the photocell on the north side of the building on the roof. The sensor reading shall be 0-750 foot-candles.

2.07 CONTROL VALVES

A. Furnish all valves controlled by the EMCS as shown on the Mechanical Drawings. Furnish all automated isolation valves as shown on the Mechanical Drawings. Control valves shall be factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. EMCS contractor to size control valve with a maximum of 3 psi pressure drop. 2-position isolation valves shall be full-line size.
   1. All chilled water, condenser water, and hot water valves shall meet, at minimum, the following ANSI Class 150 ratings. Valves 0.5 inch to 2 inches shall have NPT female threaded ends. Valves 2.5 inches and larger shall have flanged ends.
   2. Equal Percentage control characteristic shall be provided for all water coil control valves.

B. Pressure Independent Characterized Control Ball Valves ½” to 6”, for two-way modulating applications shall have equal percentage characteristics and control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSI across the valve. The

pressure independent control valve shall be provided and delivered from a single manufacturer as a complete assembly. The actuator shall be integrally mounted to the valve at the factory with a single screw on a direct coupled DIN mounting-base. All valve actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow and/or temperature control. Programming using actuator mounted switches or multi-turn actuators are not acceptable. The control valves shall be sized for the scheduled flow and not pressure drop. Calibrated Balancing Valves and Automatic Flow Limiting Valves shall be prohibited from use at coil circuit piping where pressure independent control valves are installed. Contractor shall provide a section of straight pipe five times the pipe diameter with respect to the nominal valve size upstream of the control valve assembly where utilizing integral flow sensor to guarantee sensor accuracy.

1. NPS 3/4” and Smaller: Belimo PIQCV or equal. Forged brass body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, characterizing disc integral to ball, PTFE ball seat, dual EPDM lubricated O-rings, and female NPT union ends. Close off pressure rating of 100 psi. Integral pressure regulator located upstream of ball to maintain a constant pressure differential. Replaceable cartridge type regulators are not permitted.
2. NPS 1” through 2”: Belimo ePIV or equal. Forged brass, nickel-plated body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, PTFE ball seat, dual EPDM lubricated O-rings, stainless steel or TEFZEL characterizing disc, and female NPT union ends. Close off pressure rating of 200 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.
3. NPS 2-1/2” through 6”: Belimo ePIV or equal. GG25 cast iron body according to ANSI 125, Class B, stainless steel ball and blowout-proof stem, PTFE ball seat, with a dual EPDM lubricated O-rings and a stainless steel flow characterizing disc. End connection pattern to match ANSI 125 flange. Close off pressure rating of 100 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.

C. Characterized Control Ball Valves (CCV) for ½’ to 2”: for 3-way modulating applications shall have equal percentage characteristics. Manufacturer shall be Belimo or approved equal. Balancing valves shall be provided in all coil circuits that utilize 3-way control valves.
   1. Valve housing shall consist of forged brass rated at no less than 400 psi at 250 °F. Three-way valves shall have EPDM O-rings behind ball seals to allow for a minimum close-off pressure of 40 psi with an actuator that provides 35 in-lbs torque for ½ to 2 in. sizes. Three-way valves shall be installed in a “tee” configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.

D. Globe Valves 2-1/2” to 6”: for 3-way modulating applications shall have equal percentage characteristics. Manufacturer shall be Belimo G7 series or approved equal. Balancing valves shall be provided in all coil circuits that utilize 3-way control valves.
   1. Valve housing shall consist of cast iron rated at no less than 125 psi at 300 °F. Valve shall have stainless steel stem, plug and seat. Three-way valves shall be installed in a “tee” configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.

E. Butterfly valves: For chiller and cooling tower isolation control valves, butterfly control valves may be provided.
   1. Butterfly Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats. Butterfly valves shall have ductile iron body, 304 stainless steel disc and EPDM seat. The valve body close-off pressure rating shall be 150 psi over a range of -20 °F to 250 °F. The flange shall be ANSI 125/250. Provide Belimo Series F6 and F7 or Bray Series 3L.

F. Actuators for characterized control valves and globe valves: Provide electric actuators for all control valves that are furnished as part of the EMCS contract. Two-way and three- way control valve actuators shall meet, at minimum, the following requirements:
   1. Motor driven type with gear assembly made of hardened steel. Actuator shall have an input voltage of 24 VAC. Provide visual mechanical position indication.
   2. Actuators installed within the interior of the building envelope shall be provided with NEMA-2 rated housings.
   3. Actuators installed exterior to the building envelope shall be provided with NEMA-4 rated housings or a weather shield. All penetrations through exterior actuator housings shall be provided with fittings that prevent water ingress.
   4. Valves shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head. Actuators shall control against system maximum working pressures.
   5. Normal and failure positions shall be as indicated in the operating sequences. Provide spring return action per the sequences.
   6. Manual declutch lever to enable manual operation of the valve. It shall be possible for an operator to manually modulate valves located in mechanical rooms in the event of loss of power.
   7. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
   8. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
   9. Electric actuators shall be Belimo, compatible with the valves furnished.

G. Butterfly Valve Industrial Actuators
   1. Enclosure shall be NEMA 4 (weatherproof) enclosure and will have an industrial quality coating.
   2. Actuator shall have a motor rated for continuous duty. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on a 120 VAC, 1 phase, 60 Hz supply. Two adjustable cam actuated end travel limit switches shall be provided to control direction of travel. A self-resetting thermal switch shall be imbedded in the motor for overload protection.
   3. Reduction gearing shall be designed to withstand the actual motor stall torque. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
   4. Actuator shall have a 6 ft wiring harness provided for ease in field wiring (above 1500 in-lbs). Two adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC shall be provided for indication of open and closed position. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
   5. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator and when in manual operation electrical power to the actuator will be permanently interrupted. The hand wheel will not rotate while the actuator is electrically driven.
   6. The actuator shall be analog, floating, or two position as called out in the control sequence of operation. All analog valves shall be positive positioning, and respond to a 2-10 VDC, 4-20 mA, or adjustable signal as required. Analog actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.
   7. Butterfly valve actuators shall be Belimo or Bray furnished with specified butterfly valves.

2.08 PANELS AND ENCLOSURES

A. Provide panels and enclosures for all components of the EMCS, which are susceptible to physical or environmental damage.

B. Interior panels and enclosures shall meet be NEMA 1 rated painted steel panels with locking door.

C. Exterior mounted panels and enclosures shall be NEMA 4 painted steel panels with locking door.

D. Panels for USCs shall be mounted on the outside of all unit ventilators and fan coil units with three feet of wall clearance in front of them and no higher than 7 feet to the bottom of the panel.

2.09 LABELING AND WARNING NOTICES

A. Provide labeling for all control panels and enclosures.

B. Provide labeling of all control wires and input/output points at the controller and at the control device; the label at each end of the wire shall be the same Labels shall be machine generated, typed and clearly legible with a maximum of 17 characters. Hand written labels or labels written on the control wire jacket will not be acceptable. Each label shall be unique to its function and shall reference the applicable system. For example “AHU-1 SAT” will indicate the supply air temperature sensor for AHU-1. Improper labeling shall be removed and shall require re-commissioning of the control device and controller to document correct functionality.

C. Provide high voltage warning notices at all equipment controlled by the EMCS and at all associated motor starters when used by equipment controller.

2.10 TUBING AND PIPING

A. Provide tubing and piping as required for the field instrumentation.

B. Tubing within equipment rooms, vertical risers, and penetrations to ductwork shall be either copper pipe or shall be plastic tubing within conduit. Tubing for all water-based instrumentation shall be copper pipe. Identify the type of tubing proposed in the shop drawing submittal.

C. Provide suitable bulk head fittings for duct and panel penetrations.

D. Tubing in plenum rated areas may be plastic tubing. Polyethylene tubing shall meet, at minimum, the following requirements: flame retardant; crack resistant; 300 psi burst pressure.

2.11 CONDUIT AND FITTINGS

A. Provide all conduits, raceways and fittings for the EMCS monitoring, communication and control cabling. All work shall meet all applicable codes.

B. Conduit, where required, shall meet, the requirements specified within Division 26.

C. EMCS monitoring and control cable shall not share conduit with cable carrying voltages in excess of 90 VAC.

2.12 CABLING

A. Provide all cables for the EMCS. Cable shall meet, at minimum, the following requirements:
   1. Minimum 98% conductivity stranded copper.
   2. Proper impedance for the application as recommended by the EMCS component manufacturer.
   3. Monitoring and control cable shall be #18 AWG or larger, dependent on the application. Analog input and output cabling shall be shielded.
   4. Management Level Network cable shall be CAT 6, 24 gauge unshielded.
   5. Automation Level Network cable shall be #24 AWG shielded.
   6. Shield shall be grounded at the CCP, UC, or control panel. Ground at one end only to avoid ground loops.
   7. Identification of each end at the termination point. Identification should be indicated on and correspond to the record drawings.

B. 120 VAC power wiring shall be of #12 AWG solid conductor or larger as required.

PART 3 - EXECUTION

3.01 PRE-CONSTRUCTION

A. The EMCS supplier shall provide a pre-construction coordination meeting with the affected trades to ensure a cooperative efficient process of installation. The invited trades shall include the general contractor, mechanical contractor, electrical contractor, test and balance contractor, commissioning provider, owner's representative, consulting engineer and others with a direct interest in the coordination of the affected systems. The EMCS contractor shall provide an outline of the meeting agenda highlighting the construction schedule, coordination with mechanical and electrical trades. Provide a sign-in sheet and submit it through the attendees along with a summary of the meeting notes for future reference.

3.02 INSPECTION DURING INSTALLATION

A. Provide a technician to assist the Engineer or Owner's Representative with inspections made during the installation period that are required to review the progress and quality of ongoing work. The engineer/owner's representative shall generate field observation reports on the findings of the inspection. The engineer or owner's representative shall advise the EMCS contractor during the inspection of any concerns noted with respect to the installation and shall repeat the concerns in writing as soon as possible after the inspection is completed. The EMCS contractor shall take corrective action to meet the requirements of the specifications. Upon correction, the EMCS contractor shall submit written documentation through the contractors to the engineer.

3.03 INSTALLATION OF COMPONENTS

A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with specification Division 26 and all national, state and local electrical codes.

B. Provide wire and wiring techniques recommended by equipment manufacturers. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in. Provide auxiliary pilot duty relays on motor starters as required for control function.

C. Electrical Contractor shall provide 120 or 277 volt power at a junction box within 48" of the controller. The BAS Contractor shall coordinate with the Electrical Contractor to identify locations of power requirements prior to the installation of the controls.

D. Conduit for control wiring shall be provided whenever one of the following conditions exists:
   1. Conduit is indicated on the drawings or specifically required by the specifications.
   2. Cabling runs through inaccessible areas such as within partitions/walls, above closed in ceilings, under floor; within trenches and underground; on the exterior of the building; exposed on the surface of the building; when encased in concrete or other material that makes the cable inaccessible or when located such that access to the cable is not readily obtained.
   3. Cable within mechanical, telecommunications and electrical equipment rooms and control rooms.

E. Control wiring located above an accessible ceiling space may be plenum rated cable. Plenum rated wire shall be bundled and routed at right angles to the building lines and secured to the building structure every 15 feet.

F. Control wiring located in underground conduits shall be provided with direct-burial-rated insulation.

G. When communication bus enters or exits a building, a surge suppressor shall be installed. The surge suppressor shall be installed according to the controls manufacturer's instructions.

H. Provide sleeves for all cable and conduit passing through walls, partitions, structural components, floors and roof.

I. All sensor wiring shall be labeled to indicate the origination (at the device) and destination of data (at the control panel). The description shall indicate the type and location of the control device such as “AHU-1 SA temp” or “VAV 1-1 space temp”.

3.04 VERIFICATION REQUIREMENTS

A. Verification shall be provided by the EMCS contractor to demonstrate and confirm that the installed system complies with the specifications and the control sequences of operation herein specified. upon completion of the verification process the EMCS contractor shall demonstrate to the engineer or owner’s representative the functionality of the control system devices are in compliance with the contract documents.

B. Technicians provided by the EMCS contractor shall be factory trained and qualified in the operation of the provided control system. The EMCS contractor shall provide, if requested, the factory training certificates of the individuals providing the verification services on this project.

C. Verification tools, applicable to the system provided, shall be utilized by the factory-trained technicians for proper verification of system operation and functionality. Temperature verification sensors shall be NIST certified within the last 12 months. Meters such as Fluke 52 series or better shall be utilized. Use of non-certified meters may require the system to be re-verified with certified meters at no cost to the owner.

D. Documentation of the verification process shall be provided per the project general conditions in electronic PDF format as required. Documentation shall include the following forms:
   1. Project System Verification Forms for each controller provided on the project to verify the proper function of each controller, control device and system component provided.
   2. Panel Verification Forms for each control panel to document the proper installation and function of each control panel provided.
   3. Sequence of Operation Verification Forms for each piece of controlled equipment to confirm compliance of the control system with the specified sequences of operation.
   4. Not providing proper documentation for each control devices, panel, or system, upon request by the engineer or owner’s representative, may require the EMCS contractor to re-verify the applicable systems at no additional cost to the owner.

E. After completion of the verification, the EMCS contractor shall be able to demonstrate the sequence of operations for each system to the engineer and the owner’s representative.

F. Equipment checkout sheets are to be produced by this contractor showing checkboxes and compliance with the following procedures for each piece of equipment and turned over to the owner and/or mechanical engineer.

3.05 COLOR GRAPHICS

A. The color graphics shall be provided for the EMCS system prior to system acceptance and owner training.

B. The color graphics provided shall include the following as a template. Provide forward and backward links on the graphic.
   1. Site plan with link to overall building plan including detached buildings. The site plan shall be referenced to an automatically updated aerial view or map view of the area such as Google Maps or Bing Maps. Provide link to proceed to the overall building floor plan.
   2. The overall building plan shall indicate space temperature conditions referenced by the color of the zone. Specific details of the zone temperatures and equipment are not required. Provide a link to the floor plan wings, upper floors and remote buildings.
   3. The colorgraphics for the equipment shall as a minimum be equal to the points from the input/output summary or control schematic. Primary control devices as required by the sequences of operation shall also be provided.
   4. Control points from equipment that are integrated into the EMCS via BACnet shall be provided to convey the operating conditions of the attached equipment. Coordination of the integration points shall be accomplished during the submittal phase. The EMCS contractor shall provide a list of all integrated points on their submittal.

3.06 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Startup testing documentation: Prepare the checklist documenting startup testing of each input and output device, with technician's initials and date certifying each device has been tested and calibrated prior to acceptance testing. This document shall indicate proof that the following functions have been commissioned and shall be included in the as-built documentation: short to ground check, configuration of trends, confirmation that color-graphics are accurately representing actual systems, point to point checkout, all damper and valve actuators respond to input change, control modules are addressed and have functional descriptors, specified interlocks are functional, calibration report of all sensors, discrete outputs respond to time schedule or manual enable command.

B. Demonstration. Prior to acceptance, demonstrate the following performance tests to demonstrate system operation and compliance with specifications.
   1. Engineer, owner’s representative and mechanical contractor shall be invited to observe and review system demonstration. Provide attendees at least 10 days notice.
   2. Demonstration shall follow process approved as part of the submittal and shall include complete checklists and forms for each system as part of system demonstration.
   3. Demonstrate actual field operation of each sequence of operation as specified. Demonstrate calibration and response of any input and output points requested by engineer or owner’s representative.
   4. Demonstrate complete operation of operator interface including review of color-graphics, time schedules, trend logs, alarm notification, functionality of tablet PC operation.
      a. PID loop response. Supply graphical trend data output showing each PID loop's response to a set point change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be selectable from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values.
      b. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand limiting setpoint, and status of set points and other affected equipment parameters.
      c. Trend logs for each system. Trend data shall indicate set points, operating points, valve positions, and other data as specified. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.
   5. Alarms and Interlocks. Check each alarm with an appropriate signal at a value that will trip the alarm. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction. Alarm verification shall include temperatures exceeding alarm threshold (high and low), fan failure safety, duct high static pressure switch, freezestat, and smoke detector shutdown.
   6. Tests that fail to demonstrate proper system operation to the engineer shall be repeated after contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

C. Owner Acceptance.
   1. After tests described in this specification are performed to the satisfaction of both engineer and owner’s representative, the engineer shall accept the control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond EMCS contractor's control. Engineer shall provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
   2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved by the engineer.

3.07 DEMONSTRATION AND OWNER TRAINING

A. Furnish basic operator training for multiple persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 16 hours: 8 hours instructor time for onsite training and 8 hours of hands on class environment training. Training sessions may be provided in 4-hour increments as approved by the owner's representative.
   1. Change/modify temperature setpoints.
   2. Change/modify time of day, holiday and override schedules.
   3. Display, create, and modify trends of system points.
   4. Update room numbers on the color-graphics.

B. Demonstrate complete and operating system to Owner. Provide written documentation listing the attendees of the specified training with sign-in sheet and training time and date.

3.08 SEQUENCE OF OPERATIONS

A. Refer to the Mechanical Drawings for project control schematics and sequence of operations.

END OF SECTION 23 0963

SECTION 23 2113
HYDRONIC PIPING AND FITTINGS

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).

B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.

C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard; 2025.

D. ASME B16.9 - Factory-Made Wrought Buttwelding Fittings; 2024.

E. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges; 2021.

F. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.

G. ASME B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series); 2012 (Reaffirmed 2021).

H. ASME B31.1 - Power Piping; 2024.

I. ASME B31.9 - Building Services Piping; 2025.

J. ASME B36.19M - Welded and Seamless Wrought Stainless Steel Pipe; 2022, with Errata (2023).

K. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2025.

L. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2025, with Errata .

M. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2024.

N. ASTM A105/A105M - Standard Specification for Carbon Steel Forgings for Piping Applications; 2024.

O. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2019a.

P. ASTM A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished; 2024.

Q. ASTM A197/A197M - Standard Specification for Cupola Malleable Iron; 2000, with Editorial Revision (2023).

R. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2025.

S. ASTM A276/A276M - Standard Specification for Stainless Steel Bars and Shapes; 2025.

T. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength; 2021.

U. ASTM A312/A312M - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes; 2025.

V. ASTM A536 - Standard Specification for Ductile Iron Castings; 2024.

W. ASTM B32 - Standard Specification for Solder Metal; 2020.

X. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.

Y. ASTM B813 - Standard Specification for Water Flushable Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2024.

Z. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings; 2023.

AA. ASTM D2996 - Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe; 2023.

BB. ASTM D4024 - Standard Specification for Machine Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Flanges; 2022.

CC. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.

DD. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2025.

EE. AWS D10.12M/D10.12 - Guide for Welding Mild Steel Pipe; 2000.

FF. AWWA C606 - Grooved and Shouldered Joints; 2022.

1.02 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Chilled-water piping.
   2. Air-vent piping.
   3. Safety-valve-inlet and -outlet piping.

1.03 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

1.04 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature, unless otherwise indicated:
   1. Chilled-Water Piping: 250 psig at 200°F.
   2. Air-Vent Piping: 200°F.
   3. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.05 SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe.
   2. Fittings and accessories.
   3. Valves.
      a. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   4. Air control devices.
   5. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding certificates.

D. Qualification Data: For Installer.

E. Cleaning/Flushing Plan: This must be submitted and approved prior to any piping being installed. Plan, including all steps to be taken to ensure the piping installation will be cleaned properly prior to: service, circulation through equipment, or connection to another system. This shall include, but not be limited to:
   1. A step by step explication of the process.
   2. Drawing(s) indicating flow (gpm) values required to meet the minimum velocity in each pipe.
   3. Drawing(s) indicating the phase(s) in which the system will be cleaned as required to ensure the minimum velocity will be maintained in each section of piping. It is expected that multiple phases will be required to achieve the minimum velocities in all of the piping safely.

4. Drawing(s) indicating locations of the required temporary connections, valves, strainers, and bypasses.
5. Cutsheet of the temporary pump to be used during flushing.
6. Water treatment and pipe cleaning chemicals.

F. Field quality-control test reports.

G. Submit certification of welder's qualifications to perform the required welding operations.

H. Operation and maintenance data:
1. For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

I. All underground distribution systems shall be furnished in strict conformance to the latest edition of ASME B31.1 or local requirements, whichever is more stringent. The system shall be installed as indicated on the drawings to compensate for stresses and movement of the service pipe.

J. Victaulic products shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series number.

1.06 QUALITY ASSURANCE

A. All piping shall be trackable to its country of origin.

B. Provide domestic manufactured piping and fittings.

C. Installer Qualifications:
1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

D. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

E. Welding: Qualify processes and operators according to ASME BPVC-IX.
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

F. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC-VIII-1.

G. Grooved Fittings:
1. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components
2. A Victaulic factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. A Victaulic representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.
3. A manufacturer's factory trained inspector (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. The manufacturer's inspector will inspect installation. The contractor shall remove and replace any improperly installed products. Upon completion of the manufacturer's inspection of the installation, the manufacturer shall supply the owner with an extended 30-year product warranty. The warranty shall cover the cost of part and labor for repairing any leaking piping and joints.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect piping, valves, fittings, etc. before installation in accordance with manufacturer's written instructions.

B. Piping shall be shipped from the factory with capped ends and stored on supports off the ground with ends covered at all times to prevent nesting of insects, birds, and other animals. Any pipe found to be without endcaps or not raised off of the ground should be cleaned by the contractor prior to installation.

C. Protect piping from accumulation of dirt and debris in and around piping/components.

1.08 OPERATION AND MAINTENANCE DATA

A. Operation and maintenance manuals shall include the following information:
   1. The approved submittal with all approved items present (not a partial resubmittal)
   2. Chemicals used in cleaning, flushing, inhibiting, and final water treatment.
   3. Water quality test reports from the cleaning process.

1.09 EXTRA MATERIALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

B. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 STEEL PIPING AND FITTINGS

A. 2 inches and less in diameter: ASTM A53/A53M, Grade B, standard-weight seamless or electric-resistance welded black steel pipe with standard-weight malleable iron threaded fittings, satisfying ASME B16.3 and ASTM A197/A197M.

B. 2-1/2 inches to 10 inches in diameter: ASTM A53/A53M, Grade B, standard-weight seamless or electric-resistance welded black steel pipe with standard-weight seamless steel welded fittings, satisfying ASTM A234/A234M, Grade WPA or WPB, ASME B16.9.

C. For pipe 12 inches and larger in diameter, provide standard-weight pipe meeting the requirements of ASTM A53/A53M or ASTM A106/A106M Grade B seamless or ERW black steel pipe with standard-weight seamless black steel welding fittings satisfying ASTM A234/A234M grade WPA or WPB, ASME B16.9.
   1. For piping over 24 inches at the contractor’s option, provide standard-weight ASTM 139 Spiral Weld black steel pipe with standard-weight seamless steel welded fittings, satisfying ASTM A234/A234M, Grade WPA or WPB, ASME B16.9.

2.02 COPPER PIPING AND FITTINGS

A. ASTM B88, hard drawn Type L seamless copper tube with wrought copper fittings, ASME B16.22.

2.03 FIBERGLASS PIPE AND FITTINGS

A. RTRP: ASTM D2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.

B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.

C. Flanges: ASTM D4024. Full-face gaskets suitable for the service, minimum 1/8-inch thick, 60-70 durometer. ASTM A307, Grade B, hex head bolts with washers.

D. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

2.04 JOINTS

A. Screwed (Steel Piping, 2” and smaller):
   1. Make screwed joints using machine-cut ANSI taper pipe threads.
   2. Apply suitable joint compound, such as Teflon tape to the male threads only.
   3. Ream pipe to full inside diameter after cutting. All-thread nipples are not permitted.

B. Dissimilar Metals: Make joints between copper and steel pipe and equipment along with steel pipe and ductile iron pipe using insulating unions.

1. Provide insulating unions as manufactured by Crane, EPCO Sales, Inc. or approved equivalent.

C. Solder Joints (Copper Piping):
   1. Prior to making joints, cut pipe square and ream to full diameter. Clean exterior of pipe and socket. Apply thin coat of suitable fluxing compound to both pipe and socket, and fit parts together immediately.
   2. Heat assembled joint only as required to cause the solder to flow. Run the joint full, slightly beaded on the outside, and wipe to remove excess solder.
   3. Utilize lead free solder. Use silver brazing alloy or Sil-Fos on refrigerant piping and on underground piping.

D. Press Fittings
   1. At Contractor's option press fittings may be used with copper piping
   2. Allowable Manufacturers
      a. Viega (Pro-Press)
      b. Joints may also be joining method with a non-toxic synthetic rubber elastomer seal (EPDM O-RINGS) with the fitting socket. The fitting shall be pressed under substantial pressure by RIDGID power toll forming a joint rated for 200 psi and tested for 600 psi,
      c. For piping 2" and smaller provide wrought-copper fitting with EPDM O-rings with fitting sockets. Fittings shall be pressed under pressure forming a joint rated for 200 psi and tested for 600 psi.
      d. Fittings shall have identification to indicate that a fitting is unpressed. Unpressed fittings shall leak under hydrostatic test.

E. Welded (Steel Piping, 2-1/2" and larger):
   1. Make welded joints as recommended by the standards of the American Welding Society.
   2. Ensure complete penetration of deposited metal with base metal.
   3. Provide filler metal suitable for use with base metal.
   4. Keep inside of fittings free from globules of weld metal.
   5. Do not use mitered joints.
   6. Use standard weld elbow fittings for changes of direction or cut a standard elbow for odd angles.

F. Flanged:
   1. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe and equipment. Align bolt holes to straddle the vertical, horizontal or north-south centerline. Do not exceed 3/64 inch per foot inclination of the flange face from true alignment.
   2. Use flat-face companion flanges only with flat-faced fittings, valves or equipment. Otherwise, use raised-face flanges.
   3. Install proper gaskets, suitable for intended service and factory cut to proper dimensions. Red rubber gaskets are not acceptable. Garlock gaskets or EPDM shall be used. Apply non-stick clean surface lubricant coating to both sides of gaskets.
   4. Use ANSI nuts and bolts, galvanized or black to match flange material. Use galvanized steel nuts and bolts underground, coated with two coats of coal tar enamel. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets. Use anti-seize compound on all bolts above and below grade. Bolt threads not to protrude more than 2 threads past nut.
   5. Use carbon steel flanges conforming to ASME B16.5 with materials conforming to ASTM A105/A105M, Grade II or ASTM A108, Grade II. Use welding neck type flanges at all fittings and on all pipe.
   6. Flanges for ductile iron pipe are specified in sections using that pipe.
   7. Keep flange covers on equipment and shop-fabricated piping until ready to install in system.

2.05 GROOVED FITTINGS

A. Acceptable Manufacturers: Victaulic Company of America

B. Where allowed in application table in Part 3 of this specification, Victaulic press type fittings are allowed for piping 2 inches and smaller.

C. Where allowed in application table in Part 3 of this specification, Victaulic grooved mechanical couplings are allowed for piping 2-1/2 inches and larger.

D. Press Type Fittings:
   1. At Contractors option, ½" through 2" ASTM A312/A312M, Type 304/304L, Sch. 10S, pipe, dimensions conforming to ANSI/ASME B36.19M for chilled and heating hot water systems as indicated in the application table in Part 3.
   2. Vic-Press 304™: ASTM A312/A312M stainless steel housings with ASTM A276/A276M and ASTM A312/A312M outlets and austenitic stainless steel plain or grooved ends, type 304, complete with synthetic rubber Grade "E" EPDM for applicable services to +250 Deg F. System shall be rated to 500 psi unless noted otherwise.
      a. Flange Adapters: ANSI Class 150 flange adapter, Van Stone type with stainless steel back-up flange and Vic-Press™ ends. Rated for services to 275 psi. Victaulic Style P565.
      b. Unions: Threaded union, 304/304L stainless steel, with Vic-Press™ ends. Victaulic Style P584.

E. Grooved Mechanical Couplings:
   1. At Contractors option, roll or cut groove couplings, pipe, and fittings may be used in lieu of weld, flange or screwed joints for chill water, hot water and condenser water systems where indicated in the application table in Part 3.
   2. All grooved end fittings shall be domestic made ductile iron conforming to ASTM A536; wrought steel conforming to ASTM A234/A234M. Grooved ends shall conform with AWWA C606. Adjoining couplings shall consist of two ductile iron housing segments, pressure-responsive gasket, and zinc-electroplated steel bolts and nuts. Factory-fabricated fittings from steel pipe are not allowed. Branch connections must meet the requirements of steel piping called out in this specification, regardless if it is factory-fabricated or field-fabricated.
      a. 2" through 12": Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +250 deg F
         1) Rigid Type: Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and ASME B31.9. Victaulic Style 107.
         2) Flexible Type: For use in locations where vibration attenuation and stress relief are required. Three flexible couplings may be used in lieu of a flexible connector. The couplings shall be placed in close proximity to the source of the vibration. Victaulic Installation-Ready Style 177. Where Style 177 is not available in the pipe size required, use a Style 77 coupling.
            (a) 14" through 60": Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.
               (1) Rigid Type: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ASME B31.1 and ASME B31.9. Victaulic Style W07.
               (2) Flexible Type: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement. Victaulic Style W77.
               (3) Flange Adapter: Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741 / W741.

3) In applicable locations and applications, Use Victaulic 177 flexible type couplings on expansion loops in accordance with the latest Victaulic recommendations for expansion compensation.

F. Unions are not required in installations using grooved mechanical joint couplings. (The couplings shall serve as unions and disconnect points.)

2.06 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

D. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. 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.

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

2.07 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company.
      b. Central Plastics Company.
      c. Hart Industries International, Inc.
      d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
   2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180°F.

D. Dielectric Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Calpico, Inc.
      b. Lochinvar Corporation.
   2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.

E. Dielectric Flanges:
   1. Manufacturers:
      a. Capitol Manufacturing Company.
      b. Central Plastics Company.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      d. CTS Flange Co.
   2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

F. Dielectric-Flange Kits:
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
      e. FNW
   2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

G. Dielectric Nipples:
   1. Manufacturers:
      a. Perfection Corporation; a subsidiary of American Meter Company.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Company, Inc.
      d. Victaulic Company of America.
      e. Matco-Norca
   2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225°F.

2.08 UNIONS

A. Use 150-pound standard (300-pound WOG) malleable iron, ground joint unions with bronze seat. Provide flanged union joints on piping larger than 2-1/2 inches.

2.09 BRANCH CONNECTIONS

A. For Pipe 2 inches and smaller, use threaded fittings for steel pipe. For threaded piping, use straight size of reducing tee.

B. For 2-1/2 Inches through 20 inches: For welded piping, when branch size is the same as and one size smaller than header size, use welding tee. Use Weldolet when branch is two or more sizes smaller than header. For threaded branch connections, use thread-o-let welded to header.

2.10 GASKETS

A. Provide gaskets between flanges of all flanged joints. Inside diameter of gaskets shall conform to nominal pipe size. Gaskets shall be ring type between raised face flanges and full face between flat face flanges with punched bolt holes and pipe opening.

B. Gaskets shall be cut from 1/8-inch-thick non-metallic, non-asbestos gasket material suitable for operating temperatures from -150°F to +750°F. Garlock or equal. For pipe smaller than 6 inches, use 1/16-inch-thick gasket.

2.11 FLOOR AND CEILING PLATES

A. Provide chrome-plated floor and ceiling plates around pipes exposed to view and passing through walls, floors, partitions, or ceilings in finished areas. Size plates to fit pipe or insulation and securely lock in place.

PART 3 - EXECUTION

3.01 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the top of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

N. Press connections: Copper and copper alloy press connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer

O. Install valves according to the appropriate section.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blow off connection for strainers smaller than NPS 2.

S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 23 05 16, Expansion Fittings and Loops for HVAC Piping.

T. Identify piping as specified in the above referenced specification section.

U. Support piping adequately to maintain line and grade, with due provision for expansion and contraction.

V. Use only long radius elbows on steel and copper piping unless a short radius elbow is specifically shown on the drawings.

W. Slope condensate drain piping at a minimum 1/8 inch per foot in the direction of flow.

X. Provide dielectric union or flange at connections of dissimilar metals, including equipment connections.

3.02 WELDING

A. Weld and fabricate piping in accordance with ASME B31.9, latest edition, Code for Pressure Piping. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

B. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

C. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.

D. Do not split, bend, flatten or otherwise damage piping before, during or after installation.

E. Remove dirt, scale and other foreign matter from inside piping before tying in sections, fittings, valves or equipment.

3.03 OFFSETS AND FITTINGS

A. Because of the small scale of drawings, the indication of all offsets and fittings is not possible. Carefully investigate the structural and finish conditions affecting the work and take such steps as may be required to meet such conditions.

B. Install all piping close to walls, ceilings and columns so piping will occupy the minimum space. Provide proper space for covering and removal of pipe, special clearances, and for offsets and fittings.

C. Install piping as to not obstruct any equipment or architectural access doors.

3.04 ISOLATION VALVES

A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections at each floor and at branch takeoffs serving equipment, and at other locations as indicated and required for isolation of piping or equipment.

B. At air handling units, where multicoil (stacked) arrangement is used, provide each supply and return line to and from each stacked coil section with a union, pressure gauge and thermometer well and a balancing valve (with memory stop) for balancing, and valves for isolation of each coil. Refer to mechanical details for additional requirements.

3.05 DRAIN VALVES AND VENTS

A. Install drain valves at all low points and at base of all risers of water piping systems so that these systems can be entirely drained.

B. Install 2-inch drain for 2 -inch pipes and larger.

C. Install a line size drain valve for pipes smaller than 2 inches.

D. Provide hose adapter and cap on all drain lines.

E. Provide automatic vents with isolation valves or manual vents at locations as indicated on Drawings and all high points in piping systems.

3.06 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

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

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

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

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.07 PROFESSIONAL FLUSHING AND CLEANING OF PIPING SYSTEMS

A. Flushing and cleaning of the HVAC related piping shall be provided by a third-party flushing company.

B. Accptable vendors include the following:
1. PurgeRite, www.purerite.com

C. Requirements:
1. Do not use building pumps for circulating water.
2. Provide temporary pumps as required to achieve minimum velocities.
3. Remove flow meters from building piping during flushing operation.
4. Provide means (instrumentation) during flushing period to prove to the Owner that the minimum velocities are maintained in the pipes.
5. For copper piping, maintain the flushing velocity between 3 (min) and 5 (max) feet per second. Limit temperature of water inside piping to a maximum 140°F.
6. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves, and other equipment where permanent strainers are not indicated. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blow off valve.
7. Provide bypasses at the following equipment as close as feasibly possible to the equipment (no more than 10 feet total of piping at each piece of equipment) and isolate equipment as required (temporary blind flanges or similar):
   a. Hydronic coils
   b. Chillers
8. After systems have been flushed and cleaned; as required by specifications, provide written certification from the cleaning contractor that the systems are clean and ready for use. This shall include the water quality report comparing the make-up water to the water circulated in the piping after removal of chemicals to verify pipe condition.

D. Submit a detailed plan for the Engineer’s and Owner's review and approval describing in full detail the individual steps associated with this process before any piping is installed.
1. Refer to Submittal section above for further requirements.

E. Flushing & Cleaning of Carbon Steel Piping System
1. After the mechanical contractor has tested the piping, it is to be flushed and cleaned for service. Provide a complete water flushing and cleaning of the closed loop chilled and hot water systems as specified herein. Systems must be commissioned as clean and meet water treatment specifications.
2. All chilled, and hot water piping and related equipment shall be thoroughly flushed out with pre-cleaning chemicals designed to remove deposits such as pipe dope, oils, loose rust, mill scale and other extraneous materials. Recommended dosages of pre-cleaner chemical products shall be furnished by water treatment supplier, added, and circulated throughout the water systems. The water system shall then be diluted and final flushed thoroughly until no foreign matter is observed and total alkalinity of the water is equal to or better that that of the make-up water.
3. All temporary connections required for flushing, cleaning, purging, and circulating shall be included. Provide suitable pipe bypasses at each coil and heat exchanger during the flushing and cleaning operation.
4. Flushing equipment will include a pump(s) and inline filtration, that will meet or exceed the volume required to flush and purge the system at the required velocity rate through the largest pipe. Pump curve will be submitted along with other important documentation for the related equipment on the unit. This will include, at minimum, filtration type, flow

meter(s), pressure gauges, and unit description or picture. All operators will comply with all safety regulations of the project site. The flushing operation will be manned continuously during the flushing process.

5. Flushing Procedure Guidelines
   a. Pre-Flush – Bypass loops should be installed in front of any strainers and control valves at all equipment components when possible. Coordinate with PurgeRite for proper sizing and placement of bypasses and flush ports.
      1) Bypass or Install temporary strainer elements in front of pumps, tanks, solenoid valves, control valves, and other equipment where permanent strainers are not indicated that are not bypassed. Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blow-off valve. Strainers should be removed when external flush pumps are used in conjunction with filtration.
      2) Flush ports should be identified along with the type of high-pressure or other hose/piping that will be used to connect to the system. The water source should be identified and must be adequate to fill and make up water in a timely manner to the system during the flush process. A water dump location should be identified as well, which is usually the sanitary.
   b. Clear-Water Flush – Fill the piping system with clean potable water. The first flush is a clear-water flush intended to circulate water through the system and force loose debris to low point drains and filtration system. This flush should be at minimum of 5 ft./sec. throughout. Filtration should be 50 microns at minimum. This flush shall continue until the system water is comparable to the make-up water. Iron content should be under 2.0 ppm.
   c. Cleaning & Passivation – The second flush cycle is a combined flushing cycle where cleaning and passivation chemicals are introduced into the system to clean the oils and treat the inside wall of the piping system. This process will be monitored by the chemical treatment company to meet the chemical specifications of the water. The cleaning velocity should be between 3-5 ft./sec. throughout. The circulation duration will be based on the chemical testing—24 hours at minimum.
   d. Final Clear Water Flush – The system will be continuously flushed while discharging chemicals into the approved sanitary system. As the existing treated water is being discharged, a freshwater make-up source will be utilized to ensure air is not introduced into the system. Continue to drain the system while adding domestic water to dilute the treated water. The chemical treatment company will monitor the outgoing water composition and compare the composition with the incoming water. Flush with fresh water until the conductivity is reduced to that of the make-up water and iron meets specifications. The final system water should be approved by the chemical treatment company. Filtration should be 5 microns at minimum.
   e. Final Chemical Fill – Once the chemical treatment company has determined the system has been brought back to the correct composition, the chemical treatment company will inject the final chemicals into the system. Once the system is filled with the final chemicals it is important the water is not left stagnant.
      1) Verify satisfactory completion of clean piping and a final flushing and chemical treatment report should be submitted by field personnel. The report should include at minimum, project name, date, location, parties involved, type of pipes treated, scope summary, flows, durations, and other relevant information.
      2) Cleaning chemicals, procedure, water testing, reporting, and consultation must be provided by a qualified water treatment company specializing in this type of work.

3.08 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. 3Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure, minimum 150 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.09 PIPING APPLICATION SCHEDULE

A. Provide piping and fittings meeting the requirements of Part 2 as identified in the table below:

Service	Pipe Sizes	Pipe Material
Chilled Water Piping	2” and smaller	Copper or Steel
Chilled Water Piping	2-1/2” and larger	Steel
Heating Hot Water Piping	2” and smaller	Copper or Steel
Heating Hot Water Piping	2-1/2” and larger	Steel
Condensate Piping	All	Copper
Condenser Water Piping	All	Steel
Makeup-Water Piping	All	Copper or Steel
Blowdown-Drain Piping	All	Steel
Air-vent Piping	All	Copper or Steel
Safety-valve inlet and outlet piping	All	Same as for piping system for which it is installed

Cryogen Vent Piping	All	Sch. 10-304 S.S. or Copper Type L

3.10 GROOVED END APPLICATION TABLE

A. Grooved end piping and fittings are allowed on this project in the locations identified in the application table below:

Service	Location	Pipe Sizes
Chilled & Heating Hot Water Piping	Mechanical Rooms & Exterior locations	2-1/2" and larger
Condenser Water Piping	Mechanical Rooms	2-1/2" and larger

END OF SECTION 23 2113

SECTION 23 2114
HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.01 REFERENCE STANDARDS

A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2025, with Errata .

1.02 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 230200 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.03 WORK INCLUDED

A. Air vents.

B. Strainers.

C. Relief valves.

D. Pressure and temperature test plugs.

1.04 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

B. Conform to ASME BPVC-VIII-1 for manufacturer of tanks.

1.05 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division One.

B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division One.

B. Store and protect products under provisions of Division One.

1.07 OPERATIONS PERSONNEL TRAINING

A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
   4. How the equipment achieves its purpose and necessary operating conditions.
   5. Most likely failure modes, causes and corrections.
   6. On site demonstration.

PART 2 - PRODUCTS

2.01 AIR VENTS

A. Acceptable Manufacturers
   1. Armstrong.
   2. Bell and Gossett/ITT Hoffman.
   3. IMI Flow Design.

B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

C. Float Type: Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

D. Washer Type: Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.02 ACCEPTABLE MANUFACTURERS - STRAINERS

A. Armstrong.

B. Bell and Gossett.

C. IMI Flow Design.

D. Mueller Steam Specialty.

2.03 ACCEPTABLE MANUFACTURERS - STRAINERS (GROOVED ONLY)

A. Victaulic

2.04 STRAINERS

A. Size 2 inch and Under: Threaded brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

B. Size 2-1/2 inch to 4 inch: Flanged or grooved iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

C. Size 6 inch and Larger: Flanged or grooved iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.05 ACCEPTABLE MANUFACTURERS - PUMP SUCTION FITTINGS

A. Bell and Gossett.

B. TACO.

2.06 ACCEPTABLE MANUFACTURERS - PUMP SUCTION FITTINGS (GROOVED ONLY)

A. Victaulic

2.07 PUMP SUCTION FITTINGS

A. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged or grooved for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.

B. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.08 ACCEPTABLE MANUFACTURERS - RELIEF VALVES

A. Bell and Gossett.

B. McDonnell-Miller.

C. TACO.

2.09 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.10 ACCEPTABLE MANUFACTURERS - PRESSURE AND TEMPERATURE TEST PLUGS

A. Peterson Equipment Company

2.11 PRESSURE AND TEMPERATURE TEST PLUGS

A. Test plugs shall be designed to receive temperature or pressure probe. Plugs shall be solid brass with two valve cores of Neoprene (Max 200°F service), fitted with removable protective

cap, cap retaining strap, and gasket. Provide plugs with extension neck to match pipe insulation thickness.

PART 3 - EXECUTION

3.01 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer`s instructions to permit intended performance.

B. Support tanks inside building from building structure in accordance with manufacturer`s instructions.

C. Where large air quantities can accumulate, provide enlarged air collection standpipes.

D. Provide automatic air vents at all high points and air pockets in the system. Where automatic air vents are installed above a ceiling or in other concealed locations, provide vent tubing to nearest drain.

E. Provide manual air vents as indicated on details and drawings.

F. Provide valved drain and hose connection on strainer blow down connection.

G. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.

H. Support pump fittings with floor mounted pipe and flange supports.

I. Provide relief valves on pressure tanks; and on low pressure side of reducing valves, heat exchangers, and expansion tanks.

J. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

K. Pipe relief valve outlet to nearest floor drain.

L. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

M. Provide pressure and temperature test plugs at the inlet and outlet of all coils, coil control valves, heat exchangers, strainers, pumps, and at all other locations indicated on the drawings.

END OF SECTION 23 2114

SECTION 23 2123
HVAC PUMPS

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ANSI/HI 1.3 - ROTODYNAMIC CENTRIFUGAL PUMPS FOR DESIGN AND APPLICATION; 2013.

B. ANSI/HI 1.4 - Rotodynamic Centrifugal Pumps for Manuals Describing Installation, Operation, and Maintenance; 2014.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.

1.02 SUMMARY

A. This Section provides furnishing and installing the following hydronic pumps:
   1. Base mounted end suction pumps

1.03 PUMP SELECTION REQUIREMENTS

A. Select pumps conservatively for scheduled conditions. Furnish pumps which have reasonably high efficiencies, with peak efficiency at or near rated conditions. Select pumps that will operate stably at 15-foot suction lift despite substantial reduction in head or substantial increase in delivery.

B. Provide motor-driven pumps of the type and speed scheduled. Select pumps that are not overloaded throughout the entire range of pump operation. Provide pump connection sizes as scheduled.

C. If the pumps proposed are not considered suitable, submit manufacturer's data on other pumps, for review.

D. Unless otherwise indicated the maximum pump selections shall be limited to 60 HZ.

1.04 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

C. Indicate pump's operating point on curves. Include NPSH curve when applicable.

D. Wiring Diagrams: Power, signal, and control wiring.

E. Short-circuit current rating of equipment assembly.

F. Submit information on electric motors per requirements and indicating compliance with Section 23 05 13. Motor data must be submitted with pump submittal. No exceptions.

G. Submit manufacturer’s installation instructions under provisions of Section 23 00 10.

H. Provide a letter of certification from pump manufacturer that unit was manufactured, and factory assembled by pump manufacturer.

I. Simultaneous Action Submittals: Hydronic Pump Product Data submittal shall be made in conjunction with action submittals required under Division 26 Section “Overcurrent Protective Device Coordination Study.” The release of mechanical equipment submittals (pumps, air handling units, chillers, fans cooling towers, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section “Submittal Procedures” to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01

requirements shall provide for this review time in the action submittal process. Delay claims arising due to Contractor’s failure to coordinate simultaneous action submittals will not be considered by the Owner.

1.05 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 , Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 10.

B. Include installation instructions, assembly views, lubrication instructions and replacement parts list.

C. Include copy of approved submittal, vibration test results and certified pump curve with final balancing point indicated.

D. Include letter of certification stating that pump was factory assembled by pump manufacturer.

1.07 COORDINATION

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

1.08 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.09 EXTRA PARTS

A. Provide one extra set of mechanical seals for each pump.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Products meeting all requirements of this specification section of the following manufacturers are acceptable
   1. Armstrong Pumps
   2. Bell & Gossett
   3. Taco
   4. Grundfos/Paco

2.02 GENERAL HYDRONIC PUMP REQUIREMENTS

A. Provide hydronic pumps of the type, rotational speed and arrangement indicated and scheduled; each rated to deliver the capacity indicated in the tabulation on the Drawings against the head of the system in which it operates.

B. Provide each centrifugal pump with an impeller whose diameter is 90% or less of the maximum impeller which the manufacturer shows in his published curves for that pump. Pump selection

shall be such that variation of plus or minus 15% of head estimated can be accomplished by "trimming" impellers by the manufacturer.

C. Impellers shall only be trimmed by manufacturer or an authorized manufacturer's representative.

D. Efficiencies for the pumps selected for submittal shall be equal to or greater than the efficiency of the scheduled pumps at the scheduled design conditions.

E. Provide each pump with a constant speed or variable speed (as scheduled), premium efficiency, with minimum efficiencies as listed in Division 23 Common Motor Requirements for HVAC Equipment, ODP motor, unless noted to be a TEFC, wound for operation on the current characteristics indicated in the tabulation on the Drawings. Size each motor with relation to the pump impeller so that the required brake horsepower will not exceed the rated motor horsepower at any point on the pump curve.

2.03 BASE MOUNTED END SUCTION PUMPS

A. Description: Pump assembly including motor, coupling, pump and baseplate factory assembled and tested at pump manufacturer's plant.

B. Casing:
1. Cast iron, volute type, centrifugal pump with Class 125 ANSI flanged connection and tapped openings for vent and drain, equipped with petcocks.
2. Casing for pumps 3" x 4" and larger must accommodate an impeller 15 percent greater in diameter than the impeller actually selected to meet specified performance.
3. Design casings to provide for complete removal of bearing, seals and impeller without disturbing piping connections to pumps.

C. Impellers: Furnish enclosed, cast bronze impeller, keyed and locked to the shaft, statically and hydraulically balanced.

D. Wearing Rings: Provide bronze, renewable wearing rings on all pumps 1 1/2" and larger.

E. Shaft: Furnish stainless steel shaft, turned and ground to accurate dimension, of ample size to prevent deflection and key slotted as required. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. In order to improve serviceability and reduce the cost of ownership the shaft sleeve must be slip on (press on not allowable) and must be easily replaced in the field

F. Bearings: The pump bearing frame shall incorporate maintenance free permanently lubricated and sealed bearings with an L10 life of 60,000 hours. Bearing frame shall be equipped with seals to protect bearings from moisture and airborne contaminants.

G. Mechanical Seals: The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250ºF. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity.

H. Pedestals: Furnish cast iron pump and bearing pedestal for pedestal-mounted pumps. Machine the pump bracket for rabbet jointing to pump casing. Precision bore the bearing support to provide accurate alignment between bearings and pump.

I. Couplings: Provide flexible mechanical coupling as manufactured by Woods rated for the full rated horsepower of the driving motor at motor speed.

J. Base Plates: Factory install the pump assembly and the motor on a common rigid hot dipped galvanized steel or cast-iron base fabricated and arranged to ensure rigid and true alignment of pump and motor shafts.
1. Furnish base plate with drip rim sloped to tapped drain opening. Base plate to extend beyond full width of pump flanges.
2. Base plate to have openings to facilitate grouting of the base plate to inertia base.

K. Provide manufacturer's factory representative certification for alignment of the pumps. Manufacturer shall inspect pump installation after grouting is complete and certify pump

alignment is in accordance with manufacturer's instructions and that the installations comply with the manufacturer's warranty requirements.

L. Motors: Provide motors suitable for VFD (Variable Frequency Drive - pulse width type). Combination of drive and pump shall not produce objectionable noise or vibration throughout operative range of pump.

M. Name Plates. Nameplates and other data plates shall be stainless steel, suitably secured to the pump. Provide one spare stainless-steel performance nameplate with each pump that is insulated, and field install on pump base.

N. Test run VFD pumps with motor at all speeds prior to shipping to ensure that pump assembly will not experience unacceptable levels of vibration during operation.

2.04 MOTORS

A. Motors for base mounted pumps shall be mounted with pump on baseplate at pump manufacturer's plant and shipped as one unit.

B. Pump and motor shall be factory aligned and shall be realigned by the Contractor after installation.

C. Motors shall be 1800 rpm except as otherwise scheduled ODP (for indoor application). Equipment manufacturers shall certify in the submittal data that the motors furnished with the pumps are compatible with the variable frequency drives (include manufacturer and Model number) to be installed on this project. If motors are incompatible with VFDs, pump manufacturer shall provide and install new motors at no change in contract price. Refer to Section 23 05 13 for additional motor requirements. Provide Aegis shaft grounding ring for pumps driven by VFDs where required in Specification 23 05 13.

2.05 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 300-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

B. Triple-Duty Valve: Angle or straight pattern, 300-psig pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

C. Provide additional isolation valve on discharge side of triple duty valve.

2.06 RATINGS

A. Short-Circuit Current: Match rating of overcurrent protective device serving enclosed controller assembly.

B. Available Short-Circuit Current: As indicated on the Drawings. Refer to Division 26 Section "Overcurrent Protective Device Coordination Study" for additional requirements.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.02 INSTALLATION

A. Comply with ANSI/HI 1.4.

B. Install according to manufacturer's printed recommendations and pipe as shown on drawings. Install pumps with access (minimum 2'-6") for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. The Contractor shall level each pump and grout each pump base.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
   1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
   2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

F. Automatic Pumping Traps shall be installed per the manufactures recommendations but shall be installed to provide for access and maintenance of all components.

G. Route drain from drip pan to nearest floor drain.

H. Stored pumps shall have shafts rotated at least once a month.

I. Name Plates: Install spare nameplate as required in Part 2 of this Specification.

3.03 ALIGNMENT

A. Lubricate pumps prior to start-up. Provide manufacturer's factory representative certification for alignment of the pumps. Factory technician shall inspect pump installation after grouting is complete and certify pump alignment is in accordance with manufacturer's instructions and that the installations comply with the manufacturer's warranty requirements.

B. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

C. Comply with pump and coupling manufacturers' written instructions.

D. Adjust pump and motor shafts for angular and offset alignment by methods specified in ANSI/HI 1.3 and ANSI/HI 1.4.

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

F. Use only stainless-steel shims.

3.04 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install triple-duty valve on discharge side of pumps with additional isolation valve on discharge side.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install strainer, check valve, isolation valves, pipe supports and other devices as shown on the detail.

H. Install pressure gauges on pump suction and discharge, at integral pressure-gauge tapping, or install single gage with multiple input selector valve.

I. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

J. Install electrical connections for power, controls, and devices.

K. Connect wiring according to Section 26 05 19, Insulated Conductors.

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

M. Install each VFD scheduled according to Division 26 Section “Variable Frequency Motor Controllers”

3.05 VIBRATION TESTING

A. Vibration velocity readings shall be taken at all bearing locations of all pumps. Pumps driven by variable speed drives shall be tested throughout their range of speeds. Vibration shall not exceed 0.15 inch/second (peak). Record and deliver copies of the test report to the Owner and include report in the O&M Manual.

3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
   6. Start motor.
   7. Open discharge valve slowly.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 2123

SECTION 26 0010
SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2025.

B. AWS D1.2/D1.2M - Structural Welding Code - Aluminum; 2014, with Errata (2020).

C. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components; 2010, with Editorial Revision (2020).

D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. NFPA 70E - Standard for Electrical Safety in the Workplace; 2024.

G. NFPA 110 - Standard for Emergency and Standby Power Systems; 2025.

H. PS 1 - Structural Plywood; 2023.

I. PS 2 - Performance Standard for Wood Structural Panels; 2019.

J. UL 62368-1 - Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements; Current Edition, Including All Revisions.

1.02 SUMMARY

A. This Section specifies supplemental requirements generally applicable to the Work specified in Division 26. This Section is also referenced by related Work specified in other Divisions.

B. Related Requirements:
   1. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.03 ABBREVIATIONS AND DEFINITIONS

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:
   1. 8P8C: An 8-position 8-contact modular jack.
   2. A: Ampere, unit of electrical current.
   3. AC or ac: Alternating current.
   4. AFCI: Arc-fault circuit interrupter.
   5. AIC: Ampere interrupting capacity.
   6. AL, Al, or ALUM: Aluminum.
   7. ASD: Adjustable-speed drive; also called variable-frequency drive (VFD).
   8. ATS: Automatic transfer switch.
   9. AWG: American wire gauge; see ASTM B258.
   10. BAS: Building automation system.
   11. BIL: Basic impulse insulation level.
   12. BIM: Building information modeling.
   13. CAD: Computer-aided design or drafting.
   14. CATV: Community antenna television.
   15. CB: Circuit breaker.
   16. cd: Candela, the SI fundamental unit of luminous intensity.
   17. CO/ALR: Copper-aluminum, revised.
   18. COPS: Critical operations power system.
   19. CU or Cu: Copper.
   20. CU-AL or AL-CU: Copper-aluminum.
   21. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.

22. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
23. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
24. dBm: Decibel absolute power with respect to 1 mW.
25. DC or dc: Direct current.
26. DCOA: Designated critical operations area.
27. DDC: Direct digital control (HVAC).
28. EGC: Equipment grounding conductor.
29. ELV: Extra-low voltage.
30. EMF: Electromotive force.
31. EMI: Electromagnetic interference.
32. EPM: Electrical preventive maintenance.
33. EPS: Emergency power supply.
34. EPSS: Emergency power supply system.
35. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
36. FLC: Full-load current.
37. ft: Foot.
38. ft-cd: Foot-candle, the antiquated U.S. Standard unit of illuminance, equal to one international candle measured at a distance of one foot, that was superseded in 1948 by the unit "footcandle" after the SI unit candela (cd) replaced the international candle; see "fc,"
39. GEC: Grounding electrode conductor.
40. GFCI: Ground-fault circuit interrupter.
41. GFPE: Ground-fault protection of equipment.
42. GND: Ground.
43. HACR: Heating, air conditioning, and refrigeration.
44. HDPE: High-density polyethylene.
45. HID: High-intensity discharge.
46. HP or hp: Horsepower.
47. HVAC: Heating, ventilating, and air conditioning.
48. Hz: Hertz.
49. IBT: Intersystem bonding termination.
50. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
51. IP: Ingress protection rating (enclosures); Internet protocol (communications).
52. IR: Infrared.
53. IS: Intrinsically safe.
54. IT&R: Inspecting, testing, and repair.
55. ITE: Information technology equipment.
56. kAIC: Kiloampere interrupting capacity.
57. kcmil or MCM: One thousand circular mils.
58. kV: Kilovolt.
59. kVA: Kilovolt-ampere.
60. kVAr or kVAR: Kilovolt-ampere reactive.
61. kW: Kilowatt.
62. kWh: Kilowatt-hour.
63. LAN: Local area network.
64. lb: Pound (weight).
65. lbf: Pound (force).
66. LCD: Liquid-crystal display.

67. LCDI: Leakage-current detector-interrupter.
68. LED: Light-emitting diode.
69. Li-ion: Lithium-ion.
70. lm: Lumen, the SI derived unit of luminous flux.
71. LRC: Locked-rotor current.
72. LV: Low voltage.
73. lx: Lux, the SI derived unit of illuminance equal to one lumen per square meter.
74. m: Meter.
75. MCC: Motor-control center.
76. MDC: Modular data center.
77. MG set: Motor-generator set.
78. MIDI: Musical instrument digital interface.
79. MLO: Main lugs only.
80. MV: Medium voltage.
81. MVA: Megavolt-ampere.
82. mW: Milliwatt.
83. MW: Megawatt.
84. MWh: Megawatt-hour.
85. NC: Normally closed.
86. NIU: Network interface unit.
87. NO: Normally open.
88. NPT: National (American) standard pipe taper.
89. OCPD: Overcurrent protective device.
90. ONT: Optical network terminal.
91. PC: Personal computer.
92. PCS: Power conversion system.
93. PCU: Power-conditioning unit.
94. PF or pf: Power factor.
95. PHEV: Plug-in hybrid electric vehicle.
96. PLC: Programmable logic controller.
97. PLFA: Power-limited fire alarm.
98. PoE: Power over Ethernet.
99. PV: Photovoltaic.
100. PVC: Polyvinyl chloride.
101. pW: Picowatt.
102. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
103. RMS or rms: Root-mean-square.
104. RPM or rpm: Revolutions per minute.
105. SCADA: Supervisory control and data acquisition.
106. SCR: Silicon-controlled rectifier.
107. SPD: Surge protective device.
108. sq.: Square.
109. SWD: Switching duty.
110. TCP/IP: Transmission control protocol/Internet protocol.
111. TEFC: Totally enclosed fan-cooled.
112. TR: Tamper resistant.
113. TVSS: Transient voltage surge suppressor.
114. UL: (standards) Underwriters Laboratories, Inc.; (product categories) UL, LLC.
115. UL CCN: UL Category Control Number.
116. UPS: Uninterruptible power supply.
117. USB: Universal serial bus.
118. UV: Ultraviolet.
119. V: Volt, unit of electromotive force.

120. V(ac): Volt, alternating current.
121. V(dc): Volt, direct current.
122. VA: Volt-ampere, unit of complex electrical power.
123. VAR: Volt-ampere reactive, unit of reactive electrical power.
124. VFC: Variable-frequency controller.
125. VOM: Volt-ohm-multimeter.
126. VPN: Virtual private network.
127. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
128. W: Watt, unit of real electrical power.
129. Wh: Watt-hour, unit of electrical energy usage.
130. WPT: Wireless power transfer.
131. WPTE: Wireless power transfer equipment.
132. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:
1. CR: Communications raceway.
2. CR-GP: General-purpose communications raceway.
3. CR-P: Plenum communications raceway.
4. CR-R: Riser communications raceway.
5. EMT: Electrical metallic tubing.
6. EMT-A: Aluminum electrical metallic tubing.
7. EMT-S: Steel electrical metallic tubing.
8. EMT-SS: Stainless steel electrical metallic tubing.
9. ENT: Electrical nonmetallic tubing.
10. EPEC: Electrical HDPE underground conduit (thin wall).
11. EPEC-A: Type A electrical HDPE underground conduit.
12. EPEC-B: Type B electrical HDPE underground conduit.
13. ERMC: Electrical rigid metal conduit.
14. ERMC-A: Aluminum electrical rigid metal conduit.
15. ERMC-S: Steel electrical rigid metal conduit.
16. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
17. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
18. ERMC-SS: Stainless steel electrical rigid metal conduit.
19. FMC: Flexible metal conduit.
20. FMC-A: Aluminum flexible metal conduit.
21. FMC-S: Steel flexible metal conduit.
22. FMT: Steel flexible metallic tubing.
23. FNMC: Flexible nonmetallic conduit. See "LFNC."
24. HDPE: HDPE underground conduit (thick wall).
25. HDPE-40: Schedule 40 HDPE underground conduit.
26. HDPE-80: Schedule 80 HDPE underground conduit.
27. IMC: Steel electrical intermediate metal conduit.
28. LFMC: Liquidtight flexible metal conduit.
29. LFMC-A: Aluminum liquidtight flexible metal conduit.
30. LFMC-S: Steel liquidtight flexible metal conduit.
31. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
32. LFNC: Liquidtight flexible nonmetallic conduit.
33. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
34. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
35. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
36. PVC: Rigid PVC conduit.
37. PVC-40: Schedule 40 rigid PVC conduit.

38. PVC-80: Schedule 80 rigid PVC Conduit.
39. PVC-A: Type A rigid PVC concrete-encased conduit.
40. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
41. RGS: See ERMC-S-G.
42. RMC: See ERMC.
43. RTRC: Reinforced thermosetting resin conduit.
44. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
45. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
46. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
47. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
48. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:
1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.
13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.
16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMUC: Under-carpet communications wire and cable.
19. CMX: Communications cable, limited use.
20. DG: Distributed generation cable.
21. FC: Flat cable.
22. FCC: Flat conductor cable.
23. FPL: Power-limited fire-alarm cable.
24. FPLP: Power-limited fire-alarm plenum cable.
25. FPLR: Power-limited fire-alarm riser cable.
26. IGS: Integrated gas spacer cable.
27. ITC: Instrumentation tray cable.
28. ITC-ER: Instrumentation tray cable, exposed run.
29. MC: Metal-clad cable.
30. MC-HL: Metal-clad cable, hazardous location.
31. MI: Mineral-insulated, metal-sheathed cable.
32. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
33. MV: Medium-voltage cable.
34. NM: Nonmetallic sheathed cable.
35. NMC: Nonmetallic sheathed cable with corrosion-resistant nonmetallic jacket.
36. NMS: Nonmetallic sheathed cable with signaling, data, and communications conductors, plus power or control conductors.

37. NPLF: Non-power-limited fire-alarm circuit cable.
38. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
39. NPLFR: Non-power-limited fire-alarm circuit riser cable.
40. NUCC: Nonmetallic underground conduit with conductors.
41. OFC: Conductive optical fiber general-purpose cable.
42. OFCG: Conductive optical fiber general-purpose cable.
43. OFCP: Conductive optical fiber plenum cable.
44. OFCR: Conductive optical fiber riser cable.
45. OFN: Nonconductive optical fiber general-purpose cable.
46. OFNG: Nonconductive optical fiber general-purpose cable.
47. OFNP: Nonconductive optical fiber plenum cable.
48. OFNR: Nonconductive optical fiber riser cable.
49. P: Marine shipboard cable.
50. PLTC: Power-limited tray cable.
51. PLTC-ER: Power-limited tray cable, exposed run.
52. PV: Photovoltaic cable.
53. RHH: (high heat) Thermoset rubber, heat-resistant cable.
54. RHW: Thermoset rubber, moisture-resistant cable.
55. SA: Silicone rubber cable.
56. SE: Service-entrance cable.
57. SER: Service-entrance cable, round.
58. SEU: Service-entrance cable, flat.
59. SIS: Thermoset cable for switchboard and switchgear wiring.
60. TBS: Thermoplastic cable with outer braid.
61. TC: Tray cable.
62. TC-ER: Tray cable, exposed run.
63. TC-ER-HL: Tray cable, exposed run, hazardous location.
64. THW: Thermoplastic, heat- and moisture-resistant cable.
65. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
66. THHW: Thermoplastic, heat- and moisture-resistant cable.
67. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
68. TW: Thermoplastic, moisture-resistant cable.
69. UF: Underground feeder and branch-circuit cable.
70. USE: Underground service-entrance cable.
71. XHH: Cross-linked polyethylene, heat-resistant cable.
72. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Definitions:
   1. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
   2. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
   3. Designated Seismic System: A system component that requires design in accordance with Ch. 13 of ASCE/SEI 7 and for which the Component Importance Factor is greater than 1.0.
   4. Direct Buried: Installed underground without encasement in concrete or other protective material.

5. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:
    a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
    b. Concrete Box: A box intended for use in poured concrete.
    c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
    d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
    e. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
    f. Device Box: A box with provisions for mounting a wiring device directly to the box.
    g. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
    h. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
    i. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
    j. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
    k. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
    l. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
    m. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.
6. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.
7. Essential Electrical Systems: (healthcare facilities) Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.
8. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.
    a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS 1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS 1 and PS 2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.
9. Jacket: A continuous nonmetallic outer covering for conductors or cables.
10. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.

11. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.
12. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
13. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.
14. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
15. Sheath: A continuous metallic covering for conductors or cables.
16. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
17. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
    a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
    b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
    c. Low Voltage (LV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
18. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.

1.04 COORDINATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:
    1. Notify JPS Project Manager no fewer than ten days in advance of proposed interruption of electrical service.
    2. Do not proceed with interruption of electrical service without JPS Project Manager’s written permission.
    3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:
        a. Exercising generators.

B. Arrange to provide temporary electrical power in accordance with requirements specified in Division 01.

1.05 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than 10 days after notice to proceed. Agenda topics include, but are not limited to, the following:
    1. Electrical installation schedule.
    2. Status of power system studies.
    3. Value analysis proposals and requests for substitution of electrical equipment.
    4. Commissioning activities.

1.06 SEQUENCING

A. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.

1.07 ACTION SUBMITTALS

A. Coordination drawings.

1.08 INFORMATIONAL SUBMITTALS

A. Electrical installation schedule.

B. Qualification statements.

C. Welding certificates.

D. Seismic-load performance certificates.

E. Delegated design drawings for structural masonry wall penetrations.

1.09 CLOSEOUT SUBMITTALS

A. Facility EPM program binders.

B. Operation and maintenance data.

C. Software and firmware operational documentation.

D. Software.

1.10 QUALITY ASSURANCE

A. Qualifications: Prepare and submit qualification statements for the following entities performing Work on Project:

1. Qualified Regional Manufacturer: Manufacturer, possessing qualifications specified in Section 014000 "Quality Requirements," that maintains a service center capable of providing training, parts, and emergency on-site repairs to Project site with response time less than two hours .
2. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering.
3. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.
4. Welder: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," with training and certification in accordance with AWS D1.1/D1.1M and AWS D1.2/D1.2M.
5. ERMC-S-PVC Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by ERMC-S-PVC manufacturer prior to starting installation.
6. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.
7. Generator Set Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by generator set manufacturer prior to starting installation.
8. Lightning Protection System Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired UL-Listed Installer, UL Category Control Number OWAY, credentials prior to starting installation.
9. Power Quality Specialist: Recognized experts possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction, and able to present unexpired NICET Level 4 credentials with documented experience in power quality testing for installations similar in complexity to this Project.
10. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

a. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

11. Structural Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing structural concrete, seismic controls, and wind-load controls.

B. Certifications:

1. Seismic-Load Performance Certificates: Provide special certification for designated seismic systems as indicated in Paragraph 13.2.2 "Special Certification Requirements for Designated Seismic Systems" of ASCE/SEI 7-05, ASCE/SEI 7-10, or ASCE/SEI 7-16 for all designated seismic-load systems identified on Drawings or in the Specifications.
   a. Include the following information:
      1) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      2) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
      3) Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
      4) Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
      5) Provide equipment manufacturer's written certification for each designated active electrical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction, or experience data as permitted by ASCE/SEI 7-05, ASCE/SEI 7-10, or ASCE/SEI 7-16 .
      6) Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-05, ASCE/SEI 7-10, or ASCE/SEI 7-16.Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by qualified structural professional engineer.

1.11 FIELD CONDITIONS

A. Modeling, analysis, product selection, installation, and quality control for Work specified in Division 26 must comply with requirements specified in Section 260011 "Facility Performance Requirements for Electrical."

B. Service Conditions for Electrical Power Equipment: Besides conditions specified in Section 260011 "Facility Performance Requirements for Electrical," specified electrical power equipment must be suitable for operation under service conditions specified as usual service conditions in applicable NEMA PB series, IEEE C37 series, and IEEE C57 series standards, except for the following:

1. Exterior Equipment:
   a. Exposure to significant solar radiation.
   b. Ambient temperature not exceeding 122 deg F (50 deg C).
   c. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
   d. Unusual transportation or storage conditions.
   e. Unusual grounding resistance conditions.
   f. Unusual space limitations.

PART 2 PRODUCTS

2.01 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

A. Substitution requests for electrical equipment will be entertained under the following conditions:
   1. Notification of Contractor's intent to request substitutions for convenience must be declared during the Electrical Preconstruction Conference so potential risks to system performance and construction schedule may be identified for Contractor's response in submission of the substitution request. Submission of requests for substitutions for convenience must meet the conditions and deadline specified in Section 012500 "Substitution Procedures" to receive approval.
   2. For electrical equipment and systems, substitutions for cause are considered major construction risks. If it is possible that Contractor may need to request substitutions for cause because of equipment unavailability, or inability to meet construction schedule because of lead time, Contractor must declare the possibility during the Electrical Preconstruction Conference to permit establishing a mitigation plan for minimizing risks to system performance and construction schedule.

PART 3 EXECUTION

3.01 PREPARATION

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:
   1. Submission of power system studies.
   2. Submission of specified coordination drawings.
   3. Submission of action submittals specified in Division 26.
   4. Orders placed for major electrical equipment.
   5. Arrival of major electrical equipment on-site.
   6. Preinstallation meetings specified in Division 26.
   7. Utility service outages.
   8. Utility service inspection and activation.
   9. Mockup reviews.
   10. Closing of walls and ceilings containing electrical Work.
   11. System startup, testing, and commissioning activities for major electrical equipment.
   12. System startup, testing, and commissioning activities for emergency lighting.
   13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
   14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
   15. Requests for special inspections.
   16. Requests for inspections by authorities having jurisdiction.

B. Coordination Drawings for Conduit Routing: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
   1. Structural members in paths of conduit groups with common supports.
   2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

3.02 INSTALLATION OF ELECTRICAL WORK

A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA 1 for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.

3.03 FIELD QUALITY CONTROL

A. Administrant for Low-Voltage Electrical Tests and Inspections:

1. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Administrant for Power-Limited Electrical Tests and Inspections:
1. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Administrant for Field Tests and Inspections of Lighting Installations:

3.04 ADMINISTER AND PERFORM TESTS AND INSPECTIONS WITH ASSISTANCE OF FACTORY-AUTHORIZED SERVICE REPRESENTATIVE CLOSEOUT ACTIVITIES

A. Operation and Maintenance Data: Prepare and submit the following:
1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:
2. Include the following information:
a. Manufacturer's operating specifications.
b. User's guides for software and hardware.
c. Schedule of maintenance material items recommended to be stored at Project site.
d. Detailed instructions covering operation under both normal and abnormal conditions.
e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
f. List of load-current and overload-relay heaters with related motor nameplate data.
g. Manufacturer's instructions for setting field-adjustable components.
h. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
i. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
j. Include copies of demonstration and training videos.

B. Training: Train Owner's maintenance personnel on the following topics:
1. How to implement updated Facility EPM Program.

END OF SECTION 26 0010

SECTION 26 0011
FACILITY PERFORMANCE REQUIREMENTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Field conditions and other facility performance requirements applicable to Work specified in Division 26.

1.02 FIELD CONDITIONS

A. Altitude:
   1. Sea level to 1000 ft. (300 m).

B. Ambient Temperature:
   1. -8 deg F to 115 def F

C. Temperature Variation: Allow for thermal movements from the following differential temperatures:
   1. Ambient Temperature Differential: 120 deg F (67 deg C).
   2. Material Surface Temperature Differential: 180 deg F (100 deg C).
   3. Ground Surface Temperature Differential to 10 ft. (3 m) Depth: 3 feet

D. Ground Water:
   1. Assume ground-water level is 36 inch (900 mm) below ground surface unless a higher water table is indicated on Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION 26 0011

SECTION 26 0519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013 (Reapproved 2024).

B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2023.

C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

D. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.

E. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.

F. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.

1.02 SUMMARY

A. Section Includes:
   1. Copper building wire.
   2. Connectors and splices.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
   3. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 PRODUCTS

2.01 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Belden Inc.
   2. Encore Wire Corporation.
   3. Okonite Company (The).
   4. Southwire Company, LLC.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Conductor Insulation:
   1. Type THHN. Comply with UL 83.
   2. Type XHHW-2. Comply with UL 44.

2.02 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. ABB, Electrification Business.
   2. Hubbell Utility Solutions; Hubbell Incorporated.
   3. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
   4. Service Wire Co.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
   1. Material: Copper.
   2. Type: One hole with standard barrels.
   3. Termination: Compression.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Branch Circuits:
   1. Copper:
      a. Solid for No. 8 AWG and smaller; stranded for No. 6 AWG and larger.
      b. Conductors No. 6 AWG and larger may be XHHW-2.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

B. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

C. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533.13 "Conduits for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

END OF SECTION 26 0519

SECTION 26 0526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Grounding and bonding conductors.
   2. Grounding and bonding clamps.
   3. Grounding and bonding bushings.
   4. Grounding and bonding hubs.
   5. Grounding and bonding connectors.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.02 DEFINITIONS

A. BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.

B. PBB: Primary bonding busbar, located in main distribution frame room, ideally near electrical service entrance.

C. RBB: Rack bonding busbar, located in equipment cabinets and racks.

D. SBB: Secondary bonding busbar, located in intermediate distribution frame rooms.

E. TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.

F. TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.

G. TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.

H. UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

1.03 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013 (Reapproved 2024).

B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2023.

C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010, with Editorial Revision (2020).

D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2020).

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. NFPA 780 - Standard for the Installation of Lightning Protection Systems; 2026.

G. UL 96 - Lightning Protection Components; Current Edition, Including All Revisions.

H. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

1.04 ACTION SUBMITTALS

A. Product Data:
   1. Grounding and bonding conductors.
   2. Grounding and bonding clamps.

3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.

B. Field quality-control reports.

PART 2 PRODUCTS

2.01 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:
1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Isolated Equipment Grounding Conductor:
1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color with one or more yellow stripes, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. ASTM - Bare Copper Grounding and Bonding Conductor:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ERICO; brand of nVent Electrical plc.
   b. Harger Lightning & Grounding; business of Harger, Inc.
2. Referenced Standards: Complying with one or more of the following:
   a. Soft or Annealed Copper Wire: ASTM B3.
   b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
   c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
   d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.
3. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
4. Listing Criteria:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDSH - Protector Grounding Conductor:
1. Description: Conductors intended to be used for grounding primary protector or metallic members of cable sheath in accordance with Chapters 7 and 8 of NFPA 70.
2. 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. Superior Essex Inc.; subsidiary of LS Corp.
3. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
4. Listing Criteria:
   a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Options:
   a. Color: green.

2.02 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.

B. Performance Criteria:

1. Regulatory Requirements:
    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
    a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
    b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. ABB, Electrification Business.
    b. B-Line; a division of Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. ERICO; brand of nVent Electrical plc.
    e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
    f. Panduit Corp.
2. General Characteristics:
    a. Two pieces with zinc-plated bolts for interior locations and stainless steel bolts for exterior location.
    b. Clamp Material: Silicon bronze.
    c. Listed for outdoor use.

D. UL KDER - Beam Grounding and Bonding Clamp :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. ABB, Electrification Business.
    b. Panduit Corp.
2. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

E. UL KDER - Exothermically Welded Connection :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. ABB, Electrification Business.
    b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    c. ERICO; brand of nVent Electrical plc.
2. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.03 GROUNDING AND BONDING BUSHINGS

A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.

B. Performance Criteria:
1. Regulatory Requirements:
    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:

a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Bonding Bushing :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
2. General Characteristics: Threaded bushing with insulated throat.

D. UL KDER - Grounding Bushing :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. Crouse-Hinds; brand of Eaton, Electrical Sector.
c. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.04 GROUNDING AND BONDING HUBS

A. Description: Hubs with certified grounding or bonding locknut.

B. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

C. UL KDER - Grounding and Bonding Hub :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Crouse-Hinds; brand of Eaton, Electrical Sector.
d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
2. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.05 GROUNDING AND BONDING CONNECTORS

A. Performance Criteria:
1. Regulatory Requirements:
a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

B. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. ABB, Electrification Business.
b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.

C. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. ILSCO.
2. General Characteristics: Compression, copper rated for direct burial terminal with set screw.

D. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. ILSCO.
2. General Characteristics: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on 5/8 or 1 inch (16 or 25 mm) centers for two-bolt connection to busbar.

E. UL KDER - Split-Bolt Service-Post Pressure-Type Grounding and Bonding Busbar Terminal :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Panduit Corp.
2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened after assembly is screwed into busbar opening.

F. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector :
1.
2. General Characteristics: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.
a. Copper, C and H shaped.

G. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. ERICO; brand of nVent Electrical plc.
2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.
a. Copper.

H. UL KDER - Signal Reference Grid Grounding and Bonding :
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. ABB, Electrification Business.
b. B-Line; a division of Eaton, Electrical Sector.
c. ERICO; brand of nVent Electrical plc.
d. Harger Lightning & Grounding; business of Harger, Inc.

2. General Characteristics: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

PART 3 EXECUTION

3.01 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR ELECTRICAL POWER

A. Grounding and Bonding Conductors:
   1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
   2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
   3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch (6 mm) in diameter.
   4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.

B. Grounding and Bonding Connectors:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Connections to Structural Steel: Welded connectors.

3.02 INSTALLATION OF GROUNDING AND BONDING FOR ELECTRICAL POWER

A. Comply with manufacturer's published instructions.

B. Reference Standards:
   1. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
   2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:
   1. Grounding and Bonding Conductors:
      a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
   2. Grounding and Bonding Connectors: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
      a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in 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.
      f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
         1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
         2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
         3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.
      g. Grounding and Bonding for Piping:
         1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main

metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Installbonding jumper to bond across flexible duct connections to achieve continuity.
i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft (18 m) apart.

3. Grounding and Bonding Busbars:
   a. Install busbar horizontally, on insulated spacers 2 inch (50 mm) minimum from wall, 6 inch (150 mm) above finished floor unless otherwise indicated.
   b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.
4. Equipment Grounding:
   a. Install insulated equipment grounding conductors with feeders and branch circuits.
   b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
      1) Feeders and branch circuits.
      2) Receptacle circuits.
      3) Three-phase motor and appliance branch circuits.

3.03 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING OF ELECTRICAL POWER

A. Field tests and inspections must be witnessed by JPS owner’s representative and commission agent. .

B. Tests and Inspections:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
   3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal. Make tests at ground rods before conductors are connected.
      a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
      c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
   4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to record of tests and observations. Include number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Nonconforming Work:
   1. Grounding system will be considered defective if it does not pass tests and inspections.
   2. Remove and replace defective components and retest.

D. Collect, assemble, and submit test and inspection reports.
   1. Report measured ground resistances that exceed the following values:
      a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω

3.04 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 0526

SECTION 26 0529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.

B. ASTM F3125/F3125M - Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi, 144 ksi, and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength; 2025.

C. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2025.

D. MFMA-4 - Metal Framing Standards Publication; 2004.

E. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.02 SUMMARY

A. Section Includes:
   1. Support, anchorage, and attachment components.
   2. Fabricated metal equipment support assemblies.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.
   1. Hangers. Include product data for components.
   2. Slotted support systems.
   3. Equipment supports.

1.04 INFORMATIONAL SUBMITTALS

A. Welding certificates.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Where support and attachment component types and sizes are not indicated, select in
   1. accordance with manufacturer's application criteria as required for the load to be supported with
   2. a minimum safety factor of 2.0. Include consideration for vibration, equipment operation, and
   3. shock loads where applicable.

2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. ABB, Electrification Business.
    b. Allied Tube & Conduit; Atkore International.
    c. CADDY; brand of nVent Electrical plc.
    d. Cooper B-line; brand of Eaton, Electrical Sector.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Plain steel.
4. Channel Width: Selected for applicable load criteria .
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel for interior applications and cold cut galvanized steel with painted ends for exterior applications, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
        1) Cooper B-line; brand of Eaton, Electrical Sector.
        2) Hilti, Inc.
        3) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        4) MKT Fastening, LLC.
2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
5. Toggle Bolts:
    a. Interior: All steel springhead type.
    b. Exterior: Stainless steel springhead type.
6. Hanger Rods: Threaded steel.

2.03 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 EXECUTION

3.01 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA NEIS 101

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

D. Comply with requirements for boxes specified in Section 260533.16 "Boxes and Covers for Electrical Systems."

E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.

F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 200 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with single-bolt conduit clamps.

G. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.02 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

B. 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 must be weight of supported components plus 200 lb.

C. 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 New Concrete: Bolt to concrete inserts.
   2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   3. To Existing Concrete: Expansion anchor fasteners.
   4. To Steel: Beam clamps (((MSS SP-58)), Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
   5. To Light Steel: Sheet metal screws.
   6. 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.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

C. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

END OF SECTION 26 0529

SECTION 26 0533
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2020).

B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

C. UL 1 - Flexible Metal Conduit; Current Edition, Including All Revisions.

D. UL 5 - Surface Metal Raceways and Fittings; Current Edition, Including All Revisions.

E. UL 5A - Nonmetallic Surface Raceways and Fittings; Current Edition, Including All Revisions.

F. UL 5B - Strut-Type Channel Raceways and Fittings; Current Edition, Including All Revisions.

G. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.

H. UL 6A - Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel; Current Edition, Including All Revisions.

I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

K. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

L. UL 360 - Liquid-Tight Flexible Metal Conduit; Current Edition, Including All Revisions.

M. UL 498 - Attachment Plugs and Receptacles; Current Edition, Including All Revisions.

N. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.

O. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.

P. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers; Current Edition, Including All Revisions.

Q. UL 514D - Cover Plates for Flush-Mounted Wiring Devices; Current Edition, Including All Revisions.

R. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.

S. UL 651A - High Density Polyethylene (HDPE) Conduit; Current Edition, Including All Revisions.

T. UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.

U. UL 797A - Electrical Metallic Tubing - Aluminum and Stainless Steel; Current Edition, Including All Revisions.

V. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings; Current Edition, Including All Revisions.

W. UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.

X. UL 1242 - Electrical Intermediate Metal Conduit-Steel; Current Edition, Including All Revisions.

Y. UL 1653 - Electrical Nonmetallic Tubing; Current Edition, Including All Revisions.

Z. UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit; Current Edition, Including All Revisions.

AA. UL 1773 - Termination Boxes; Current Edition, Including All Revisions.

BB. UL 2419 - Outline of Investigation for Electrically Conductive Corrosion Resistant Compounds; Current Edition, Including All Revisions.

CC. UL 2420 - Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings; Current Edition, Including All Revisions.

DD. UL 2515 - Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings; Current Edition, Including All Revisions.

1.02 SUMMARY

A. Section Includes:
1. Type EMT-A and Type EMT-SS raceways and elbows.
2. Type EMT-S raceways and elbows.
3. Type ENT raceways and fittings.
   a. Type EPEC raceways and fittings.
4. Type ERMC-A and Type ERMC-SS raceways, elbows, couplings, and nipples.
5. Type ERMC-S raceways, elbows, couplings, and nipples.
6. Type FMC-S and Type FMC-A raceways.
7. Type FMT raceways.
8. Type IMC raceways.
9. Type LFMC raceways.
10. Type LFNC raceways.
11. Type PVC raceways and fittings.
12. Type RTRC-AG raceways and fittings.
13. Type RTRC-BG raceways and fittings.
14. Fittings for conduit, tubing, and cable.
15. Threaded metal joint compound.
16. Solvent cements.
17. Surface metal raceways and fittings.
18. Surface nonmetallic raceways.
19. Strut-type channel raceways and fittings.
20. Wireways and auxiliary gutters.
21. Metallic outlet boxes, device boxes, rings, and covers.
22. Nonmetallic outlet boxes, device boxes, rings, and covers.
23. Termination boxes.
24. Cabinets, cutout boxes, junction boxes, pull boxes, and miscellaneous enclosures.
25. Cover plates for device boxes.
26. Hoods for outlet boxes.

B. Related Requirements:
1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).
4. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.
5. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
6. Section 270543 "Underground Pathways and Structures for Communication Systems" for exterior communications duct banks, manholes, and underground utility construction.

1.03 ACTION SUBMITTALS

A. Product Data: For the following:
1. Wireways and auxiliary gutters.

2. Surface metal raceways.
3. Surface nonmetallic raceways.
4. Floor boxes.
5. Cabinets, cutout boxes, and miscellaneous enclosures.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details. Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness at location where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.

C. Samples: For wireways, and floor boxes for colors and textures specified, 12 inch (300 mm) ???Insert dimension??? long.

1.04 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions:
1. For Type ERMC-S-PVC.

PART 2 PRODUCTS

2.01 TYPE EMT-A AND TYPE EMT-SSS RACEWAYS AND ELBOWS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 797A and UL Category Control Number FJMX.

B. Aluminum Electrical Metal Tubing (EMT-A) and Elbows:
1. Material: Aluminum.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.

C. Stainless Steel Electrical Metal Tubing (EMT-SS) and Elbows:
1. Material: Stainless steel.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.
3. Steel Electrical Metal Tubing (EMT-S) and Elbows:
4. Material: Steel.
5. Options:
a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.02 TYPE EMT-S RACEWAYS AND ELBOWS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 797 and UL Category Control Number FJMX.

B. Steel Electrical Metal Tubing (EMT-S) and Elbows:
1. Material: Steel.
2. Options:
a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 16 (trade size 1/2).
d. Colors: As indicated on Drawings.

2.03 TYPE ENT RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1653 and UL Category Control Number FKHU.

B. Electrical Nonmetallic Tubing (ENT) and Fittings:
1. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Fittings:
1) Mechanically Attached Fittings: UL 1653.
2) Solvent-Attached Fittings: UL 651.

2.04 TYPE EPEC RACEWAYS AND FITTINGS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651A and UL Category Control Number EAZX.

B. Schedule 40 Electrical HDPE Underground Conduit (EPEC-40):
1. Dimensional Specifications: Schedule 40.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

C. Schedule 80 Electrical HDPE Underground Conduit (EPEC-80):
1. Dimensional Specifications: Schedule 80.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

D. Type A Electrical HDPE Underground Conduit (EPEC-A):
1. Dimensional Specifications: Type A.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

E. Type B Electrical HDPE Underground Conduit (EPEC-B):
1. Dimensional Specifications: Type B.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

2.05 TYPE ERMC-A AND TYPE ERMC-SS RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6A and UL Category Control Number DYWV.

B. Aluminum Electrical Rigid Metal Conduit (ERMC-A), Elbows, Couplings, and Nipples:
1. Material: Aluminum.
2. Options:
a. Protective Coating: Provide protective coating for use in concrete.
b. Minimum Trade Size: Metric designator 16 (trade size 1/2).
c. Colors: As indicated on Drawings.

C. Stainless Steel Electrical Rigid Metal Conduit (ERMC-SS), Elbows, Couplings, and Nipples:
1. Material: Stainless steel.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.

2.06 TYPE ERMC-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL Category Control Number DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:
1. Exterior Coating: Zinc.
2. Options:
a. Interior Coating: Zinc with organic top coating.
b. Minimum Trade Size: Metric designator 16 (trade size 1/2).
c. Colors: As indicated on Drawings.

C. PVC-Coated-Steel Electrical Rigid Metal Conduit (ERMC-S-PVC), Elbows, Couplings, and Nipples:
1. Additional Characteristics:
a. Fittings for PVC-Coated Conduit:
1) Minimum coating thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
2) Conduit bodies must be Form 8 with an effective seal and a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury (vacuum) for 72 hours must be available. Conduit bodies must be supplied with plastic-encapsulated stainless steel cover screws.
3) Form 2 inch (51 mm) long or one pipe diameter long, whichever is less, PVC sleeve at openings of female fittings, except unions. Inside sleeve diameter must be matched to outside diameter of metal conduit.
4) PVC coating on the outside of conduit couplings must be protected from tool damage during installation.
5) Female threads on fittings and couplings must be protected by urethane coating.
6) Fittings must be from same manufacturer as conduit.
7) Beam clamps and U bolts must be formed and sized to fit outside diameter of coated conduit. Plastic-encapsulated nuts must cover the exposed portions of threads.
2. Options:
a. Exterior Coating: PVC complying with NEMA RN 1 and marked ETL Verified PVC-001.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size: Metric designator 16 (trade size 1/2).
d. Colors: As indicated on Drawings.
e. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
f. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.07 TYPE FMC-S AND TYPE FMC-A RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1 and UL Category Control Number DXUZ.

B. Steel Flexible Metal Conduit (FMC-S):
1. Material: Steel.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.

C. Aluminum Flexible Metal Conduit (FMC-A):
1. Material: Aluminum.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

b. Colors: As indicated on Drawings.

2.08 TYPE FMT RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1652 and UL Category Control Number ILJW.

B. Steel Flexible Metallic Tubing (FMT):
1. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.

2.09 TYPE IMC RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1242 and UL Category Control Number DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):
1. Options:
a. Exterior Coating: Zinc.
b. Interior Coating: Zinc with organic top coating.
c. Minimum Trade Size:
d. Minimum Trade Size: Metric designator 21 (trade size 3/4) interior locations and metric designator 27 (trade size 1) for exterior locations.
e. Metric designator 16 (trade size 1/2).
f. Colors: As indicated on Drawings.

2.10 TYPE LFMC RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 360 and UL Category Control Number DXHR.

B. Steel Liquidtight Flexible Metal Conduit (LFMC-S):
1. Material: Steel.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.

C. Stainless Steel Liquidtight Flexible Metal Conduit (LFMC-SS):
1. Material: Stainless steel.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.

2.11 TYPE LFNC RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1660 and UL Category Control Number DXOQ.

B. Layered (Type A) Liquidtight Flexible Nonmetallic Conduit (LFNC-A):
1. Additional Criteria: Type A conduit with smooth seamless inner core and cover bonded together with one or more reinforcement layers between core and cover.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

b. Colors: As indicated on Drawings.
c. Markings: 80 deg C dry.

C. Integral (Type B) Liquidtight Flexible Nonmetallic Conduit (LFNC-B):
1. Additional Criteria: Type B conduit with smooth inner surface with integral reinforcement within conduit wall.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.
c. Markings: 80 deg C dry.

D. Corrugated (Type C) Liquidtight Flexible Nonmetallic Conduit (LFNC-C):
1. Additional Criteria: Type C conduit with corrugated internal and external surfaces without integral reinforcement within conduit wall.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Colors: As indicated on Drawings.
c. Markings: 80 deg C dry.

2.12 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651 and UL Category Control Number DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:
1. Dimensional Specifications: Schedule 40.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
b. Markings: For use with maximum 90 deg C wire.

C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:
1. Dimensional Specifications: Schedule 80.
2. Options:
a. Minimum Trade Size:: Metric designator 16 (trade size 1/2).
b. Markings: For use with maximum 90 deg C wire for direct bury.

D. Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:
1. Dimensional Specifications: Type A.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

E. Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:
1. Dimensional Specifications: Type EB.
2. Options:
a. Minimum Trade Size: Metric designator 53 (trade size 2).

2.13 TYPE RTRC-AG RACEWAYS AND FITTINGS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 2515 and UL Category Control Number DZKT.

B. Heavy Wall, Low-Halogen, Aboveground Reinforced Thermosetting Resin Conduit (RTRC-AG-HW) and Fittings:
1. Additional Characteristics: Type HW.
2. Options:
a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

C. Standard Wall, Low-Halogen, Aboveground Reinforced Thermosetting Resin Conduit (RTRC-AG-SW) and Fittings:
   1. Additional Characteristics: Type SW.
   2. Options:
      a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

D. Extra Heavy Wall, Low-Halogen, Aboveground Reinforced Thermosetting Resin Conduit (RTRC-AG-XW) and Fittings:
   1. Additional Characteristics: Type XW.
   2. Options:
      a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

2.14 TYPE RTRC-BG RACEWAYS AND FITTINGS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
   2. General Characteristics: UL 2420 and UL Category Control Number DZKT, for Type BG.

B. Low-Halogen, Belowground Reinforced Thermosetting Resin Conduit (RTRC-BG) and Fittings:
   1. Options:
      a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

2.15 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Fittings for Type ERMC, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:
   1. General Characteristics: UL 514B and UL Category Control Number DWTT.
   2. Options:
      a. Material: Steel.
      b. Coupling Method: Compression coupling.
      c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
      d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

C. Fittings for Type EMT Raceways:
   1. General Characteristics: UL 514B and UL Category Control Number FKAV.
   2. Options:
      a. Material: Steel.
      b. Coupling Method: Compression coupling.
      c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
      d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

D. Fittings for Type FMC Raceways:
   1. General Characteristics: UL 514B and UL Category Control Number ILNR.

E. Fittings for Type LFMC and Type LFNC Raceways:
   1. General Characteristics: UL 514B and UL Category Control Number DXAS.

2.16 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
   2. General Characteristics: UL 2419 and UL Category Control Number FOIZ.

2.17 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL Category Control Number DWTT.
3. Sustainability Characteristics:

B. Solvent Cements for Type PVC Raceways and Fittings:

2.18 SURFACE METAL RACEWAYS AND FITTINGS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 5 and UL Category Control Number RJBT.

B. Surface Metal Raceways and Fittings with Metal Covers:
1. Options:
a. Galvanized steel base with snap-on covers.
b. Manufacturer's standard enamel finish in color selected by Architect.
c. Wiring Channels: Single.As indicated on drawings. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

C. Surface Metal Raceways and Fittings with Nonmetallic Covers:
1. Additional Characteristics: UL 94, V-0 requirements for self-extinguishing characteristics.
2. Options:
a. Galvanized steel base with snap-on covers.
b. Provide texture and color selected by Architect from manufacturer's standard colors.
c. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

2.19 SURFACE NONMETALLIC RACEWAYS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
a. UL 5A and UL Category Control Number RJTX.
b. UL 94, V-0 requirements for self-extinguishing characteristics.

B. Surface Nonmetallic Raceways and Fittings with Nonmetallic Covers:
1. Options:
a. Provide texture and color selected by Architect from manufacturer's standard colors.
b. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

C. Surface Nonmetallic Raceways and Fittings with Metallic Covers:
1. Options:
a. Manufacturer's standard enamel finish in color selected by Architect.
b. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

2.20 STRUT-TYPE CHANNEL RACEWAYS AND FITTINGS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 5B and UL Category Control Number RIUU.

B. Strut-Type Channel Raceways and Fittings with Metallic Covers:
1. Options:
a. Manufacturer's standard enamel finish in color selected by Architect.

C. Strut-Type Channel Raceways and Fittings with Nonmetallic Covers:
   1. Additional Characteristics: UL 94, V-0 requirements for self-extinguishing characteristics.
   2. Options:
      a. Provide texture and color selected by Architect from manufacturer's standard colors.

2.21 WIREWAYS AND AUXILIARY GUTTERS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
   2. General Characteristics: UL 870 and UL Category Control Number ZOYX.

B. Metal Wireways and Auxiliary Gutters:
   1. Additional Characteristics:
      a. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
      b. Finish: Manufacturer's standard enamel finish.
   2. Options:
      a. Degree of Protection: Type 1 indoor and Type 3R outdoor ???Insert type??? unless otherwise indicated.
      b. Wireway Covers: Hinged type unless otherwise indicated.

C. Nonmetallic Wireways and Auxiliary Gutters:
   1. Additional Characteristics:
      a. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings must match and mate with wireways as required for complete system.
      b. PVC Solvents and Adhesives: As recommended by wireway manufacturer.
   2. Sustainability Characteristics:
   3. Options:
      a. Material:
         1) Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover must be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections must be flanged and have stainless steel screws and oil-resistant gaskets.
         2) PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

2.22 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
   2. General Characteristics: UL 514A and UL Category Control Number QCIT.

B. Metallic Outlet Boxes:
   1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
   2. Options:
      a. Material: Sheet steel.
      b. Sheet Metal Depth: Minimum 1.5 inch (38 mm).
      c. Cast-Metal Depth: Minimum 1.8 inch (44.5 mm).
      d. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 50 lb (23 kg).

e. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb (32 kg).

C. Metallic Conduit Bodies:
1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

D. Metallic Device Boxes:
1. Description: Box with provisions for mounting wiring device directly to box.
2. Options:
a. Material: Sheet steel.
b. Sheet Metal Depth: minimum 1.5 inch (38 mm).
c. Cast-Metal Depth: minimum 1.8 inch (44.5 mm).

E. Metallic Extension Rings:
1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. Metallic Floor Boxes and Floor Box Covers:
1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. Metallic Raised-Floor Boxes and Floor Box Covers:
1. Description: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.

H. Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:
1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

I. Metallic Concrete Boxes and Covers:
1. Description: Box intended for use in poured concrete.

2.23 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 514C and UL Category Control Number QCMZ.

B. Nonmetallic Outlet Boxes:
1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
2.

C. Nonmetallic Conduit Bodies:
1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

D. Nonmetallic Device Boxes:
1. Description: Box with provisions for mounting wiring device directly to box.

E. Nonmetallic Extension Rings:
1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. Nonmetallic Floor Boxes and Floor Box Covers:

1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. Nonmetallic Raised-Floor Boxes and Floor Box Covers:
1. Description: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.

H. Nonmetallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:
1. Description: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

I. Nonmetallic Floor Nozzles:
1. Description: Enclosure intended primarily as housing for receptacle, provided with means, such as collar, for surface-mounting on floor, which may or may not include stem to support it above floor level, and is sealed against the entrance of scrub water at floor level.

J. Nonmetallic Concrete Boxes and Covers:
1. Description: Box intended for use in poured concrete.

2.24 TERMINATION BOXES

A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.

B. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1773 and UL Category Control Number XCKT.

C. Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment:
1. Additional Characteristics: Listed and labeled for installation on line side of service equipment.

D. Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment:
1. Additional Characteristics: Listed and labeled for installation on load side of service equipment.

2.25 CABINETS, CUTOUT BOXES, JUNCTION BOXES, PULL BOXES, AND MISCELLANEOUS ENCLOSURES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
a. Non-Environmental Characteristics: UL 50.
b. Environmental Characteristics: UL 50E.

B. Indoor Sheet Metal Cabinets:
1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
2. Additional Characteristics: UL Category Control Number CYIV.
3. Options:
a. Degree of Protection: Type 1.

C. Indoor Sheet Metal Cutout Boxes:
1. Description: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
2. Additional Characteristics: UL Category Control Number CYIV.
3. Options:
a. Degree of Protection: Type 1.
b. Type 1.

D. Indoor Sheet Metal Junction and Pull Boxes:
   1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   2. Additional Characteristics: UL Category Control Number BGUZ.
   3. Options:
      a. Degree of Protection: Type 1.

E. Type 1.
      a. Indoor Cast-Metal Junction and Pull Boxes:
   2. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   3. Additional Characteristics: UL Category Control Number BGUZ.
   4. Options:
      a. Degree of Protection: Type 1.

F. Indoor Polymeric Junction and Pull Boxes:
   1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   2. Additional Characteristics: UL Category Control Number BGUZ.
   3. Options:
      a. Degree of Protection: Type 1.

G. Indoor Sheet Metal Miscellaneous Enclosures:
   1. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.
   2. Options:
      a. Degree of Protection: Type 1
      b. Type 1.

H. Outdoor Sheet Metal Cabinets:
   1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
   2. Additional Characteristics: UL Category Control Number CYIV.
   3. Options:
      a. Degree of Protection: Type 3.

I. Outdoor Sheet Metal Cutout Boxes:
   1. Description: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
   2. Additional Characteristics: UL Category Control Number CYIV.
   3. Options:
      a. Degree of Protection: Type 3RType 3.

J. Outdoor Sheet Metal Junction and Pull Boxes:
   1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   2. Additional Characteristics: UL Category Control Number BGUZ.
   3. Options:
      a. Degree of Protection: Type 3R Type 3.

K. Outdoor Cast-Metal Junction and Pull Boxes:
   1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   2. Additional Characteristics: UL Category Control Number BGUZ.
   3. Options:
      a. Degree of Protection: Type 3RType 3.

L. Outdoor Polymeric Junction and Pull Boxes:
   1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.

2. Additional Characteristics: UL Category Control Number BGUZ.
3. Options:
    a. Degree of Protection: Type 3RType 3.

M. Outdoor Sheet Metal Miscellaneous Enclosures:
1. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.
2. Options:
    a. Degree of Protection: Type 3RType 3.

2.26 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
    a. Reference Standards: UL 514D and UL Category Control Numbers QCIT and QCMZ.
    b. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Metallic Cover Plates for Device Boxes:
1. Options:
    a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
    b. Wallplate Material: 0.032 inch (0.8 mm) thick Type 302/304 non-magnetic stainless steel with brushed finish.

C. Nonmetallic Cover Plates for Device Boxes:
1. Options:
    a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
    b. Wallplate Material: 0.060 inch (1.5 mm) thick high-impact thermoplastic (nylon) with smooth finish and color matching wiring device.
    c. Color:
        1) Normal:
        2) Back of house: Gray
            (a) Front of house: Ivory.
    d. Emergency: Red

D. Illuminating Cover Plates for Device Boxes:
1. Options:
    a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
    b. Wallplate Material: 0.060 inch (1.5 mm) thick high-impact thermoplastic (nylon) with smooth finish and color matching wiring device.
        1) Color:
        2) Normal:
            (a) Back of house: Gray
            (b) Front of house: White.
    c. Emergency: RedIvory.

2.27 HOODS FOR OUTLET BOXES

A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. Die Cast material
3. General Characteristics:
    a. Reference Standards:
        1) UL 514D and UL Category Control Numbers QCIT and QCMZ.

2) Receptacle, hood, cover plate, gaskets, and seals comply with UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.

b. Mounts to box using fasteners different from wiring device.

B. Retractable or Reattachable Hoods for Outlet Boxes:
1. Options:
a. Provides clear, weatherproof, "while-in-use" cover.

C. Extra-Duty, While-in-Use Hoods for Outlet Boxes:
1.
2. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
3. Options:
a. Provides clear, weatherproof, "while-in-use" cover.
b. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 EXECUTION

3.01 SELECTION OF RACEWAYS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.

B. Outdoors:
1. Exposed and Subject to Severe Physical Damage: ERMCGRC or.
2. Exposed and Subject to Physical Damage: ERMCGRC or IMC.
a. Locations less than 2.5 m (8 ft) above finished floor.
b. Electrical rooms
c. Mechanical rooms
d. ???Insert designations of applicable spaces or locations???.
3. Exposed and Not Subject to Physical Damage: ERMC: GRC IMC.
4. Concealed Aboveground: ERMC.
5. Direct Buried: PVC-80.
6. Concrete Encased Not in Trench: PVC-80.
7. Concrete Encased in Trench: PVC-80..
8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

C. Indoors:
1. Hazardous Classified Locations:: ERMC.
2. Exposed and Subject to Severe Physical Damage: ERMCGRC or IMC. Subject to severe physical damage includes the following locations:
a. Loading docks.
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.
d. Gymnasiums.
3. Exposed and Subject to Physical Damage:: ERMC GRC or IMC. Subject to physical damage includes the following locations:
a. Locations less than 2.5 m (8 ft) above finished floor.
b. Stub-ups to above suspended ceilings.
c. ???Insert designations of applicable spaces or locations???.
4. Exposed and Not Subject to Physical Damage: ERMC.
5. Concealed in Ceilings and Interior Walls and Partitions: ERMC.
6. Damp or Wet Locations: ERMCGRC or.
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC..

8. Circuits Operating Above 60 Hz: EMT-A. Provide nonmetallic sleeve where aluminum raceways pass through concrete.

D. Raceway Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
1. ERMC and IMC: Provide threaded type fittings unless otherwise indicated.

3.02 SELECTION OF BOXES AND ENCLOSURES

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:
1. Indoors:
a. Type 1 unless otherwise indicated.
b. Damp or Dusty Locations: Type 12 .Type 2.
c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4.
f. Locations Exposed to Hosedown: Type 4 .Type 6.
g. Locations Exposed to Brief Submersion: Type 6.
h. Locations Exposed to Prolonged Submersion: Type 6P.
i. Locations Exposed to Corrosive Agents: Type 4X.
j. Locations Exposed to Spraying Oil or Coolants: Type 13.

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
1. Provide cast-metal boxes.
2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.03 INSTALLATION OF RACEWAYS

A. Installation Standards:
1. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for installation of raceways. Consult Architect for resolution of conflicting requirements.
2. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
3. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
4. Comply with NECA NEIS 101 for installation of steel raceways.
5. Comply with NECA NEIS 102 for installation of aluminum raceways.
6. Comply with NECA NEIS 111 for installation of nonmetallic raceways.
7. Install raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
8. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
9. Raceway Terminations at Locations Subject to Moisture or Vibration:
a. Provide insulating bushings to protect conductors, including conductors smaller than No. 4 AWG. Install insulated throat metal grounding bushings on service conduits.

B. General Requirements for Installation of Raceways:
1. Complete raceway installation before starting conductor installation.

2. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft (0.6 m) above finished floor.
3. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch (300 mm) of changes in direction.
4. Make bends in raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
5. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
6. Support conduit within 12 inch (300 mm) of enclosures to which attached.
7. Install raceway sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings in accordance with NFPA 70.
8. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of raceways at the following points:
    a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
    b. Where an underground service raceway enters a building or structure.
    c. Conduit extending from interior to exterior of building.
    d. Conduit extending into pressurized duct and equipment.
    e. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
    f. Where otherwise required by NFPA 70.
9. Do not install raceways or electrical items on "explosion-relief" walls or rotating equipment.
10. Do not install conduits within 2 inch (50 mm) of the bottom side of a metal deck roof.
11. Keep raceways at least 6 inch (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
12. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
13. Install pull wires in empty raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb (90 kg) tensile strength. Leave at least 12 inch (300 mm) of slack at both ends of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

C. Requirements for Installation of Specific Raceway Types:
1. Types EMT-A and, ERMC-A, and FMC-A:
    a. Do not install aluminum raceways or fittings in contact with concrete or earth.
2. Types ERMC and IMC:
    a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
3. Type ERMC-S-PVC:
    a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
    b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMC-S-PVC elbows in direct-burial applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMC-S-PVC raceway.

c. Coat field-cut threads on PVC-coated raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.

4. Types FMC, LFMC, and LFNC:
   a. Comply with NEMA RV 3. Provide a maximum of 36 inch (915 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
5. Types PVC and EPEC:
   a. Do not install Type PVC or Type EPEC conduit where ambient temperature exceeds 122 deg F (50 deg C) ???Insert temperature???. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
   b. Comply with manufacturer's written instructions for solvent welding and fittings.
6. Type RTRC:
   a. Do not install Type RTRC conduit where ambient temperature exceeds 230 deg F (110 deg C) ???Insert temperature???.

D. Raceways Embedded in Slabs:
1. Run raceways larger than metric designator 27 (trade size 1) below concrete slab..
2. Arrange raceways to cross building expansion joints with expansion fittings at right angles to the joint.
3. Arrange raceways to ensure that each is surrounded by a minimum of 1 inch (25 mm) ???Insert dimension??? of concrete without voids.
4. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
5. Change from ENT to GRC or fiberglassPVC-80, before rising above floor.

E. Stub-ups to Above Recessed Ceilings:
1. Provide EMT, IMC, or ERMC for raceways.
2. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

F. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.
1. ERMC-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
2. EMT: Provide setscrew, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

G. Expansion-Joint Fittings:
1. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F (17 deg C) and that have straight-run length that exceeds 25 ft (7.6 m). Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F (55 deg C) and that have straight-run length that exceeds 100 ft (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) ???Insert temperature??? temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) ???Insert temperature??? temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) ???Insert temperature??? temperature change.
   d. Attics: 135 deg F (75 deg C) ???Insert temperature??? temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of

temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.

4. Install expansion fittings at locations where conduits cross building or structure expansion joints.
5. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

H. Raceways Penetrating Rooms or Walls with Acoustical Requirements:
1. Seal raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

3.04 INSTALLATION OF SURFACE RACEWAYS

A. Install surface raceways only where indicated on Drawings.

B. Install surface raceway with a minimum 2 inch (50 mm) radius control at bend points.

C. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch (1200) mm) and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's written instructions. Tape and glue are unacceptable support methods.

3.05 INSTALLATION OF BOXES AND ENCLOSURES

A. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.

B. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

C. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.

D. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

E. Locate boxes so that cover or plate will not span different building finishes.

F. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.

G. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.

H. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.

I. Set metal floor boxes level and flush with finished floor surface.

J. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

K. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.

L. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.

M. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
1. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
2. Provide gaskets for wallplates and covers.

3.06 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.07 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.08 CLEANING

A. Boxes: Remove construction dust and debris from device boxes, outlet boxes, and floor-mounted enclosures before installing wallplates, covers, and hoods.

END OF SECTION 26 0533

SECTION 26 0544
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2024.

B. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink); 2020.

C. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2021a.

1.02 SUMMARY

A. Section Includes:
   1. Round sleeves.
   2. Sleeve-seal systems.
   3. Sleeve-seal fittings.
   4. Grout.
   5. Foam sealants.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 PRODUCTS

2.01 ROUND SLEEVES

A. Steel Wall Sleeves:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Advance Products & Systems, LLC.
   2. General Characteristics: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. PVC Pipe Sleeves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CCI Piping Systems.
      b. GPT; a division of EnPRO Industries.
      c. Metraflex Company (The).
   2. General Characteristics: ASTM D1785, Schedule 40.

2.02 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, LLC.
   2. CALPICO, Inc.
   3. GPT; a division of EnPRO Industries.
   4. Metraflex Company (The).

B. General Characteristics: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

C. Options:
   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.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

A. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.04 GROUT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Specified Technologies Inc.
   2. W. R. Meadows, Inc.

B. General Characteristics: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
   1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
   2. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.05 FOAM SEALANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Innovative Chemical Products (Building Solutions Group).
   2. The Dow Chemical Company.

B. Performance Criteria:
   1. General Characteristics: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

PART 3 EXECUTION

3.01 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

B. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch (25 mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

C. Underground, Exterior-Wall and Floor Penetrations:
   1. Install steel pipe sleeves. Size sleeves to allow for 1 inch (25 mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

3.02 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 26 0544

SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. 29 CFR 1910 - Occupational Safety and Health Standards; Current Edition.

B. 29 CFR 1910.145 - Accident Prevention Signs and Tags; Current Edition.

C. ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.

D. ASTM D638 - Standard Test Method for Tensile Properties of Plastics; 2022.

E. ASTM D882 - Standard Test Method for Tensile Properties of Thin Plastic Sheeting; 2018.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

G. UL 969 - Marking and Labeling Systems; Current Edition, Including All Revisions.

H. UL 62275 - Cable Management Systems - Cable Ties for Electrical Installations; Current Edition, Including All Revisions.

1.02 SUMMARY

A. Section Includes:
   1. Labels.
   2. Extruded insulating tubing.
   3. Bands.
   4. Tapes and stencils.
   5. Tags.
   6. Signs.
   7. Cable ties.

B. Related Requirements:
   1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
   2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.03 ACTION SUBMITTALS

A. Product data.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 PRODUCTS

2.01 LABELS

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.

B. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil (0.08 mm) thick, polyester flexible label with acrylic pressure-sensitive adhesive.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services Inc.
d. Panduit Corp.
e. Seton Identification Products; a Brady Corporation company.

2. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
3. Marker for Labels:
   a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
   b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.02 EXTRUDED INSULATING TUBING

A. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN YDPU2 for components; including UL 224.

B. UL YDPU2 - Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at maximum of 200 deg F (93 deg C).
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Panduit Corp.

2.03 BANDS

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Marking Services Inc.
      c. Panduit Corp.
   2. Provide identification for conduits every 10 ft.

2.04 TAPES AND STENCILS

A. Underground-Line Warning Tape:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Marking Services Inc.
      c. Seton Identification Products; a Brady Corporation company.
   2. Tape:
      a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electricalutility lines.
      b. Printing on tape must be permanent and may not be damaged by burial operations.
      c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
   3. Color and Printing:
      a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.

b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW".

4. Detectable Line-Warning Tape :
   a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored,compounded for direct-burial service.
   b. Width: 6 inch (75 mm).
   c. Overall Thickness: 12 mil (0.125 mm).
   d. Foil Core Thickness: 0.35 mil (8.9 m).
   e. Weight: 28 lb/1000 sq. ft (13.7 kg/100 sq. m).
   f. Tensile in accordance with ASTM D882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

2.05 SIGNS

A. Metal-Backed Butyrate Signs:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Marking Services Inc.
   2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396 inch (1 mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
   3. 1/4 inch (6.4 mm) grommets in corners for mounting.
   4. Nominal Size: 10 by 14 inch (250 by 360 mm).

B. Laminated Acrylic or Melamine Plastic Signs:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation.
      b. Marking Services Inc.
      c. Seton Identification Products; a Brady Corporation company.
   2. Engraved legend.
   3. Thickness:
      a. For signs up to 20 sq. inch (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
      b. For signs larger than 20 sq. inch (129 sq. cm), 1/8 inch (3.2 mm) thick.
      c. Engraved legend with white letters on dark gray background.
      d. Punched or drilled for mechanical fasteners with 1/4 inch (6.4 mm) grommets in corners for mounting.
      e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.06 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. HellermannTyton.
   2. Ideal Industries, Inc.
   3. Marking Services Inc.
   4. Panduit Corp.

B. Performance Criteria:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.

C. UL ZODZ - UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F (23 deg C) in accordance with ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

PART 3 EXECUTION

3.01 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.02 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:
   1. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft (2.3 m) above finished floor.

B. Pipe and Conduit Labeling: Comply with ASME A13.1.

C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded branch-circuit conductors.
   1. Color must be factory applied or field applied for sizes larger than 6 AWG when permitted by authorities having jurisdiction.
   2. Colors for 208Y/120 V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Color for Neutral (Grounded Conductor): White
   3. Colors for 480Y/277 V Circuits:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Color for Neutral (Grounded Conductor): Gray
   4. Color for Equipment Ground: Green.

D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.

E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

F. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."

G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

H. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

I. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with conductor or cable designation, origin, and destination.

J. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with conductor designation.

K. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate to be labeled with its individual, sequential designation, composed of the following, in the order listed:
   1. Wiring closet designation.
   2. Colon.
   3. Faceplate number.

L. Branch junction boxes, on pre-printed labels, identify:
   1. Color of system
   2. Emergency (if applicable)
   3. System (Life Safety, Critical, Equipment, Normal)
   4. Voltage
   5. Identify all circuits inside the box
   6. Underline the circuits that are feeding the space.
   7. Fed from

M. VFD equipment to identify:
   1. Color of System
   2. Emergency (if applicable)
   3. System (Life Safety, Critical, Equipment, Normal)
   4. Equipment designation/Load served
   5. Voltage
   6. Phase
   7. Fed from

N. Equipment Identification Labels:
   1. Black letters on white field.
   2. Indoor Equipment: Laminated acrylic or melamine plastic sign.
   3. Outdoor Equipment: Laminated acrylic or melamine sign.
   4. Equipment to Be Labeled:
      a. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of engraved, laminated acrylic or melamine label.
      b. Variable-speed controllers.
      c. Monitoring and control equipment.

3.03 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:
   1. Safety Colors: NEMA Z535.1.
   2. Facility Safety Signs: NEMA Z535.2.
   3. Safety Symbols: NEMA Z535.3.
   4. Product Safety Signs and Labels: NEMA Z535.4.
   5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

C. Electrical Hazard Warnings:
   1. Raceways and Cables Carrying Circuits at More Than 1000 V:
      a. Black letters on orange field.
      b. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
   2. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   3. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."

D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
   a. Controls with external control power connections.

E. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

3.04 INSTALLATION

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes typical for electrical equipment environments specified in Section 260011 "Facility Performance Requirements for Electrical."

C. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

D. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

E. Verify identity of item before installing identification products.

F. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

G. Apply identification devices to surfaces that require finish after completing finish work.

H. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

I. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

L. Vinyl Wraparound Labels:
   1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
   2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

M. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

O. Self-Adhesive Labels:
   1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on 1-1/2 inch (38 mm) high label; where two lines of text are required, use labels 2 inch (50 mm) high.

P. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.

R. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
   1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

S. Underground Line Warning Tape:
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inch (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in common trenchexceeds 16 inch (400 mm) overall.
   2. Limit use of underground-line warning tape to direct-buried cables.
   3. Install underground-line warning tape for direct-buried cables and cables in raceways.

T. Nonmetallic Preprinted Tags:
   1. Place in location with high visibility and accessibility.
   2. Secure using UV-stabilized cable ties.

U. Baked-Enamel Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
   2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on minimum 1-1/2 inch (38 mm) high sign; where two lines of text are required, use signs minimum 2 inch (50 mm) high.

V. Metal-Backed Butyrate Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
   2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on 1-1/2 inch (38 mm) high sign; where two lines of text are required, use labels 2 inch (50 mm) high.

W. Laminated Acrylic or Melamine Plastic Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
   2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on 1-1/2 inch (38 mm) high sign; where two lines of text are required, use labels 2 inch (50 mm) high.

X. Cable Ties: General purpose, for attaching tags, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: UV-stabilized nylon.

END OF SECTION 26 0553

SECTION 26 0573
SHORT CIRCUIT, PROTECTIVE DEVICE COORDINATION, AND ARC FLASH STUDY

PART 1 GENERAL

1.01 RELATED DOCUMENTS AND REQUIREMENTS

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

B. One-Line Diagrams.

1.02 SUMMARY

A. For new electrical system or major system modifications, provide an engineering analysis and coordination study for the entire electrical system including existing equipment (which includes the normal and essential system). For existing electrical system additions or modifications, a partial study for new equipment and existing points of connection may be allowed by Owner. Owner will determine if the partial study will be done independently or as a modification to existing studies. As a modification to the base study, the base software files must be obtained from Owner to complete the partial study. As an independent study, connection data will be provided by Owner. Obtain Owner approval prior to performing study. The basic analysis shall include a short-circuit analysis with protective device evaluation, a protective device coordination study and an arc flash study.

B. The project shall begin at the point of the utility for the facility and continue down through the normal and emergency system, to 208Y/120V electrical equipment. Studies for existing system additions or modifications, the study may begin at the point of connection with approval. Studies shall include all new equipment.

C. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the latest edition of NFPA 70E - Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in the latest edition of NFPA 70E. The arc flash study shall encompass all normal and emergency/standby power electrical equipment.

D. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted by the engineering department of the equipment manufacturer, or an engineering firm approved by Owner. The study shall be conducted under the supervision and approval of a Licensed Professional Electrical Engineer licensed in the state of Texas and skilled in performing and interpreting the power system studies.

E. The Licensed Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies.

F. The studies shall be performed using the latest version of SKM Systems Analysis Power Tools.

G. Submit report to Engineer of Record for review prior to submitting to Owner.

H. Contractor to coordinate directly with utility company for fault information and utility overcurrent device settings.

I. There shall be a presentation of the study to Owner explaining results, issues, potential problems, and solutions.

1.03 REFERENCE STANDARDS

A. IEEE 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants; 1993 (Reaffirmed 1999).

B. IEEE 241 - IEEE Recommended Practice for Electric Power Systems in Commercial Buildings; 1990 (Reaffirmed 1997).

C. IEEE 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems; 2001, with Errata (2003).

D. IEEE 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis; 1997.

E. IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations; 2018, with Errata (2019).

F. NFPA 70E - Standard for Electrical Safety in the Workplace; 2024.

G. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

H. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

I. IEEE 1015

J. ANSI C37.13

K. ANSI C 37.41

L. ANSI C37.010

1.04 SUBMITTALS

A. General. Submit the following according to Conditions of the Contract and Division 1 Specification Sections: A preliminary short-circuit study shall be submitted to the design engineer either before or at the same time as the equipment submittals. If equipment submittals such as switchgear, switchboards, panelboards etc. are submitted without a preliminary study, they will be returned Rejected.

B. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. The report shall include the following sections:
   1. Executive Summary.
   2. Descriptions, purpose, basis, and scope of the study.
   3. Fault current calculations including a definition of terms and guide for interpretation of the computer printout.
   4. Lists or tables of all input data including all feeder data, transformer data, motor data, and electrical source data. A study 1line diagram with all same data is an acceptable alternate. Data shall be sufficient to recreate the electrical simulation to 100% without original SKM data files.
   5. Tabulations of switchboards, panelboards, circuit breakers, fuses and other protective device ratings versus calculated short circuit duties.
   6. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection.
   7. Details of the incident energy and flash protection boundary calculations.
   8. Recommendations for system improvements, where needed.
   9. One-line diagram.

C. A PDF of the final report shall be delivered to Owner.

D. A copy of the SKM model must be provided to Owner.

E. A SKM backup file must also be provided to Owner that should include all data required to replicate the study and a backup copy of the project library which shall include custom files such as special TCC curve files, or custom templates.

PART 2 PRODUCTS

2.01 DATA COLLECTION

A. The contractor shall be responsible for collecting all data for the studies.

2.02 TYPES OF STUDIES

A. Short Circuit and Protective Device Evaluation Study
   1. Short circuit analysis shall be performed to determine the available short circuit currents at all system components. A short circuit analysis and a protective device coordination study

shall always be performed when changes are made to the primary distribution system such as major upgrade replacement of primary transformers with lower or higher capacity; or lower or higher impedance transformers; additional primary service from alternate sources; operation in a different mode that increase available short-circuit current; and motor load contribution from motors greater than 20HP within the facilities. Studies shall be reviewed every five years.

a. Normal Electrical Distribution System: The normal distribution system shall be coordinated from the utility overcurrent protective device down to 208Y/120V electrical equipment.
b. Essential Electrical Distribution System: The essential distribution system shall be coordinated from the generator mounted circuit breakers down to 208Y/120V electrical equipment.

2. Provide the following as part of the study:
   a. Calculation methods and assumptions.
   b. Selected base per unit quantities.
   c. One-line diagram of the system being evaluated.
   d. Source impedance data, including electric utility system and motor fault contribution characteristics.
   e. Tabulations of calculated quantities.
   f. Results, conclusions, and recommendations.
   g. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a line to ground fault at each piece of equipment/bus.
3. Protective Device Evaluation:
   a. Evaluate equipment and protective devices and compare to short circuit ratings.
   b. Adequacy of all equipment to withstand short-circuit stresses.
4. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.
5. Transformer design impedances shall be used only when test impedances are not available.

B. Protective Device Coordination Study
1. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs. The phase curves shall be plotted on separate sheets from the ground fault curves. Show one-line comprising the protective devices on each of those sheets.
2. Plot the following characteristics on the TCC graphs where applicable:
   a. Equipment name based on Bid documents.
   b. Electric utility’s overcurrent protective device.
   c. Medium voltage (4.16kV) equipment overcurrent relay settings.
   d. Medium and low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands.
   e. Low voltage (480V and below) equipment circuit breaker trip device settings, including manufacturer’s tolerance bands.
   f. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   g. Ground fault protective devices, as applicable.
   h. Pertinent motor starting characteristics and motor damage points, where applicable.
   i. Pertinent generator short-circuits decrement curve and generator damage point.
3. Provide full coordination to 0.1 seconds per NEC wherever possible. Highlight all deficiencies with a written analysis.

C. ARC Flash Hazard Analysis
1. An arc flash analysis shall be performed based on existing short circuit values provided by the customer or in conjunction with a new short circuit study. The results from the short circuit study shall be used to determine flash protection boundary and the incident energy

at each significant location in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, industrial control panels, busways, bus plugs, large disconnects, large VFD's, large enclosed breakers where large is defined as 100A or greater) for a specified working distance. Based on the arc energy at each defined point, the proper PPE shall be determined and if the arc energy level exceeds available PPE ratings, the locations shall be noted. Labels shall be provided for each evaluated location (after approved by Owner). These labels shall list the hazard levels along with the required PPE while working in that area. Analysis shall be provided to determine if any changes can be made in protection system to reduce arc energy levels to the lowest category.

2. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum number of motors to be operating.
3. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must consider the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:
    a. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
    b. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).
4. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.
5. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
6. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
7. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
8. For existing system modifications: Studies shall include all electrical equipment electrically downstream from the new electrical equipment including both new equipment supplied under this contract and existing equipment whether supplied directly or indirectly from any of the new switchgear lineups, new substation lineup, new transformer or new generator output breaker. Print arc-flash labels and install on all new and existing electrical equipment affected by modifications. Remove existing labels after equipment is disconnected from existing upstream or breaker settings modified.
9. Incident energies above 40 cal/cm2 shall be identified with alternative reduced energy solutions if available.

D. Load-Flow/Voltage-Drop Study (If Requested by Owner)

1. A load-flow and voltage-drop study shall be performed to determine the steady-state loading profile of the system. This analysis shall be conducted under two modes of operation. The loading under the first mode of operation shall be based on the instantaneous load values collected during the field effort. The loading under the second mode of operation shall be based on 80% design criteria of the load-centers. From the results of the load-flow/voltage-drop calculations, an analysis shall be prepared, based on the NEC, to indicate areas of overloaded conductors/load-centers and areas of excessive voltage drop in the conductors. The load-flow/voltage-drop study calculations must be performed by computer utilizing a commercially available software.

E. Motor Starting Study (If Requested by Owner)
1. Motor starting study shall be prepared in order to analyze the transient effect of the system's voltage profile during motor starting. Significant motor starting voltage profile must be calculated in order to analyze the effects of the motor starting on a system basis. The voltage profile as a result of motor starting shall be analyzed based on ANSI/EEE requirements. The system loading for the motor starting study shall be in accordance with the Load-Flow/Voltage-Drop Study as detailed above. The motor starting study calculations must be performed using computer utilizing a commercially available software.

F. Harmonics Analysis (If Requested by Owner)
1. The harmonic analysis shall be performed by a computer aided simulation of the distribution system specific to this project. These calculations shall show that the total harmonic voltage distortion shall be less than 3 percent which include any contribution from all VFD's supplied.

2.03 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:
1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).
2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
3. Reactor data, including voltage rating, and impedance.
4. Generation contribution data, (synchronous generators and Utility), including short-circuit sub-transient reactance (X'"d), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.
6. Multi-color one-line diagram.

B. Short-Circuit Output Data shall include, but not be limited to the following reports:
1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage.
   b. Calculated fault current magnitude and angle.
   c. Fault point X/R ratio.
   d. Equivalent impedance.
2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage.
   b. Calculated symmetrical fault current magnitude and angle.
   c. Fault point X/R ratio.
   d. Calculated asymmetrical fault currents:
      1) Based on fault point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.

3) Based on calculated symmetrical value multiplied by 2.7.
e. Equivalent impedance.

3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage.
   b. Calculated symmetrical fault current magnitude and angle.
   c. Fault point X/R ratio.
   d. No AC Decrement (NACD) Ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis.
   g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis.

C. Recommended Protective Device Settings:
   1. Phase and Ground Relays:
      a. Current transformer ratio.
      b. Current setting.
      c. Time setting.
      d. Instantaneous setting.
      e. Recommendations on improved relaying systems, if applicable.
   2. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground).
      b. Adjustable time-current characteristic.
      c. Adjustable instantaneous pickup.
      d. Recommendations on improved trip systems, if applicable.

D. Incident Energy and Flash Protection Boundary Calculations:
   1. Arcing fault magnitude.
   2. Protective device clearing time.
   3. Duration of arc.
   4. Arc flash boundary.
   5. Working distance.
   6. Incident energy.
   7. Hazard Risk Category.
   8. Recommendations for arc flash energy reduction.

2.04 ARC FLASH HAZARD WARNING LABELS

A. Electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn qualified persons of potential of electric shock and arc flash hazards. The warning labels shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment. Arc flash warning labels shall be factory affixed to electrical distribution equipment, in compliance with NFPA 70E, by the equipment manufacturer.

B. Arc Flash hazard labels will be based on recommended overcurrent device settings and will be provided to all equipment that has been evaluated after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system and shall display the following information, but not be limited to the following:
   1. Provide Labels with “DANGER” with white letter on red background for incident energies equal to or greater than 40 cal/cm2.
   2. Provide labels with “WARNING” with black letters on an orange background for incident energies less than 40 cal/cm2.
   3. Warning of “Arc Flash Hazard and Shock Risk”
   4. Warning of shock hazard voltage. (Limited, Restricted) distances

5. Arc flash protection boundary.
6. Arc flash incident energy level (in unit of cal/cm²) for the following:
   a. 600 V and below (MCC & panelboards) at 18 inches, 455 mm
   b. 600 V and below (switchgear) at 24 inches, 610 mm
   c. Above 600 V (switchgear) at 36 inches, 910 mm
7. Appropriate Personal Protective Equipment required for both Arc-Flash and Shock Hazards: Class XX Voltage Gloves, Clothing, Safety Glasses, Voltage Rated Tools.
8. Warning of “Shock Hazard”:
   a. xxx Vac – Shock Hazard
   b. x’ – x” - Limited Approach Boundary
   c. x’ – x” - Restricted Approach Boundary
9. The label shall display appropriate electrical equipment designation and its protective device.
10. The warning and hazard labels shall not be smaller than 4-inch X 4-inch and no larger than 4-inch X 6-inch and shall be thermal transfer type labels of high adhesion, sunlight resistant, and chemical resistant polyester or vinyl for each work location analyzed.
11. Labels shall be machine printed, with no field markings.
12. A copy of every label needs to be submitted in PDF format for Owner review.
13. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings:
    a. For each 480V and 208V panelboard, one arc flash label shall be provided based on the worst case of the line and load side incident energy.
    b. For each motor control center, one arc flash label shall be provided for each section.
    c. For each low voltage switchboard, one arc flash label shall be provided for each section.
    d. For each low and medium voltage switchgear, one arc flash label shall be provided for each breaker and one arc flash label shall be provided at the rear of the gear for each section.
    e. For medium voltage switches one arc flash label each shall be provided at the front and rear of the switch (where applicable).
    f. Two arc flash labels per floor shall be provided for each bus riser and one per each bus plug.
14. Labels shall be similar to, but not necessarily exactly matching the examples in Attachment “A”.

END OF SECTION 26 0573

SECTION 26 2816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.01 REFERENCE STANDARDS

A. ASME A17.1 - Safety Code for Elevators and Escalators Includes Requirements for Elevators, Escalators, Dumbwaiters, Moving Walks, Material Lifts, and Dumbwaiters with Automatic Transfer Devices; 2022.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.

C. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.

D. NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment And Systems; 2025.

E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

F. NFPA 72 - National Fire Alarm and Signaling Code; Most Recent Edition Cited by Referring Code or Reference Standard.

G. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

H. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.

I. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

J. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.

1.02 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Shunt trip switches.
   4. Molded-case circuit breakers (MCCBs).
   5. Molded-case switches.
   6. Enclosures.

B. Related Requirements:
   1. Division 26 Section "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.03 PERFORMANCE REQUIREMENTS

A. All overcurrent protective devices (OCPD) proposed for inclusion in the Work shall be selectively coordinated with the OCPD installed on the supply side such that an overcurrent event occurring at the lowest level in the system can not cause the feeder protective device supplying the branch circuit panelboard to open. This coordination shall be carried through each level of distribution for all branches of normal and emergency down to 0.10 seconds.

B. Series-Rated devices for coordination are not permitted.

1.04 ACTION SUBMITTALS

A. Specification Compliance Certification: Submit a specification compliance certification in accordance with the Division 26 Section “Supplemental Requirements for Electrical”.

B. Submit product data and shop drawings in accordance with Division 01 and 26 Section “Supplemental Requirements for Electrical”.

C. Simultaneous Action Submittals:

1. The following equipment must be submitted in conjunction with Section “Electrical Systems Studies”
    a. All Division 26 equipment containing over current protective devices including but not necessarily limited to: Panelboards, Switchboards, Paralleling Switchgear, Generators, Overcurrent Protective devices, Variable Frequency Drives, Enclosed Switches, Circuit Breakers, Fuses, etc.
    b. Division 14 equipment controllers.
    c. Division 21/22/23 equipment controllers.
2. The release of this electrical equipment is contingent on the receipt of a complete and accurate short-circuit study.
3. The Engineer requires the full submittal period as defined in Division 01 Section “Submittal Procedures” to adequately review the study against the submitted electrical components prior to the release of submittals for equipment procurement.
4. Delay claims arising due to Contractor’s failure to coordinate simultaneous action submittals will not be considered by the Owner.

D. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
    1. Enclosure types and details for types other than NEMA EN 10250, Type 1.
    2. Current and voltage ratings.
    3. Short-circuit current ratings (interrupting and withstand, as appropriate).
    4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
    5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and ???Insert calculation program format??? electronic format.

E. Shop Drawings: For enclosed switches and circuit breakers.
    1. Include plans, elevations, sections, details, and attachments to other work.
    2. Include wiring diagrams for power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit product coordination drawings in accordance with Division 26 Section “Supplemental Requirements for Electrical” consisting of each location where enclosed switches and circuit breakers are used.

B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
    1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
        a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
        b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
    1. Fuses: Equal to three of each size and type.

1.08 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
   2. Altitude: Not exceeding 6600 feet (2010 m).

B. Interruption of Existing Electrical Service: Comply with the requirements defined in Division 26 Section “Supplemental Requirements for Electrical”.

1.09 DELIVERY STORAGE AND HANDLING

A. Prepare equipment for shipment.
   1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
   2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

B. Store equipment indoors in a clean dry space with uniform temperature in accordance with manufacture’s requirements to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. Handle equipment components according to manufacturer’s written instructions. Use factory-installed lifting provisions.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
   1. Breaker Manufacturers: Manufacturer for breakers shall be the same as the manufacturer of other breakers proposed for other portions of work.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.02 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB (Electrification Products Division).
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:
   1. Single or Double throw as indicated.
   2. Three pole.
   3. 240 or 600-V ac as indicated.
   4. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.

5. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Fuses: In accordance with specification Division 26 Section “Fuses”.

D. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 12-V dc 24-V dc.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.03 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:
1. Single or Double throw as indicated.
2. Three pole.
3. 240 or 600-V ac as indicated.
4. UL 98 and NEMA KS 1, horsepower rated.
5. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 12-V dc 24-V dc.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.04 SHUNT TRIP SWITCHES FOR ELEVATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bussmann, an Eaton business.
2. Littelfuse, Inc.
3. Mersen USA.

B. General Requirements: Comply with[ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Fusible Switch with Shunt-Trip: Manufactured unit that combines fused disconnect switch with all necessary relay(s), control transformer and other options, required to provide disconnecting means and fire protection shunt-trip interface for elevator controller.

D. Type HD, Heavy Duty:
   1. Single or Double throw fusible switch as indicated.
   2. Three pole.
   3. 240 or 600-V ac as indicated.
   4. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
   5. Integral shunt trip mechanism.
   6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

F. Accessories:
   1. Oiltight key switch for key-to-test function.
   2. Oiltight green ON pilot light.
   3. Isolated neutral lug; 100 200 percent rating.
   4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
   5. Form C alarm contacts that change state when switch is tripped.
   6. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac 24-V dc coil voltage.
   7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
   8. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   9. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
   10. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   11. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac 12-V dc 24-V dc.
   12. Hookstick Handle: Allows use of a hookstick to operate the handle.
   13. Lugs: Mechanical type, suitable for number, size, and conductor material.
   14. Service-Rated Switches: Labeled for use as service equipment.

2.05 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB (Electrification Products Division).
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; by Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 194 deg F (90 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.

F. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

G. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

H. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I-squared t response.
   5. Ground-fault alarm indication

J. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

K. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

L. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

M. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

N. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
   4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   5. Communication Capability: Circuit-breaker-mounted Universal-mounted Integral Din-rail-mounted communication module with functions and features compatible with power monitoring and control system."
   6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   8. Auxiliary Contacts: One SPDT switch Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   9. Alarm Switch: One NO NC contact that operates only when circuit breaker has tripped.
   10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

11. Zone-Selective Interlocking: Integral with electronic ground-fault trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac 208-V ac 12-V dc 24-V dc.

2.06 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB (Electrification Products Division).
   2. Eaton.
   3. Siemens Industry, Inc., Energy Management Division.
   4. Square D; by Schneider Electric.

B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

D. Features and Accessories:
   1. Standard frame sizes and number of poles.
   2. Lugs:
      a. Mechanical type, suitable for number, size, trip ratings, and conductor material.
      b. Lugs shall be suitable for 194 deg F (90 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.
   3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   6. Auxiliary Contacts: One SPDT switch Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
   7. Alarm Switch: One NO NC contact that operates only when switch has tripped.
   8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
   9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
   10. Electrical Operator: Provide remote control for on, off, and reset operations.
   11. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac 208-V ac 12-V dc 24-V dc.

2.07 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 3R, NEMA EN 10250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (((NEMA 250)) Type 1) gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (((NEMA 250)) Types 3R, 12) a brush finish on Type 304 stainless steel (((NEMA 250)) Type 4-4X stainless steel) copper-free cast aluminum alloy (((NEMA 250)) Types 7, 9).

C. Conduit Entry: NEMA EN 10250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA EN 10250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. externally operable

with the operating mechanism being an integral part of the cover (((NEMA 250)) Types 7, 9). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA EN 10250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA EN 10250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.02 PREPARATION

A. Interruption of Existing Electric Service: Comply with requirements in Division 26 Section “Supplemental Requirements for Electrical”.

3.03 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
   1. Indoor, Dry and Clean Locations: NEMA EN 10250, Type 1.
   2. Outdoor Locations: NEMA EN 10250, Type 4X.
   3. Kitchen Wash-Down Areas: NEMA EN 10250, Type 4X , stainless steel.
   4. Other Wet or Damp, Indoor Locations: NEMA EN 10250, Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA EN 10250, Type 12.
   6. Hazardous Areas Indicated on Drawings: NEMA EN 10250, Type 7 Type 9 *{font-family:"Arial";font-size:10pt;}img{max-width:300px;max-height:300px;width:225px;height:225px;}span {white-space:pre; }

3.04 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

3.05 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections for Switches:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, grounding, and clearances.
      c. Verify that the unit is clean.
      d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
      e. Verify that fuse sizes and types match the Specifications and Drawings and are from the same manufacturer.
      f. Verify that each fuse has adequate mechanical support and contact integrity.
      g. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            (a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
            (a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
      h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
      i. Verify correct phase barrier installation.
      j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
      d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
      e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:
   1. Visual and Mechanical Inspection:
      a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and clearances.
      d. Verify that the unit is clean.

e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:
    1) Use a low-resistance ohmmeter.
        (a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
        (a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
    b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
    c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
    d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
    e. Determine the following by primary current injection:
        1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
        2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
        3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
        4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.
    f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
    g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.
1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.07 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Electrical Systems Studies."

3.08 CLEANING

A. Clean components according to manufacturer's written instructions.

B. Prior to installation of front trim and cover plates inspect interior surfaces and perform the following:
1. Remove paint splatters and other spots.
2. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

C. On completion of front trim and cover installation, inspect exterior surfaces and perform the following:
1. Remove paint splatters and other spots.
2. Remove all temporary markings and labels.
3. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
4. Repair exposed surfaces to match original finish.

3.09 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

B. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's management and maintenance personnel to adjust, operate, and maintain panelboards, overcurrent protective devices, instrumentation, and accessories. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 2816